PB82-104811

# Energy Consumption in the Ohio River Basin Energy Study Region, 1974, by End User and Fuel Type

Ohio River Basin Energy Study
Urbana, IL

Prepared for

Environmental Protection Agency
Washington, DC

Apr 81

U.S. Department of Commerce
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# ENERGY CONSUMPTION IN THE OHIO RIVER BASIN ENERGY STUDY REGION, 1974, BY END USER AND FUEL TYPE

By

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Prepared for

Ohio River Basin Energy Study (ORBES)

Grant Number R805585010

Project Officer

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U.S. Environmental Protection Agency
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16. ABSTRACT

This analysis was prepared as part of the Ohio River Basin Energy Study (ORBES), a multidisciplinary policy research program supported by the Environmental Protection Agency. Energy consumption as of 1974 is calculated for the ORBES region (substantial parts of Illinois, Indiana, and Ohio, all of Kentucky, most of West Virginia, and southwestern Pennsylvania). Substate energy consumption information is obtained at the Bureau of Economic Analysis (BEA) level and aggregated across BEA areas for an approximation to the ORBES region; a set of factors is applied to allocate partial BEA area energy consumption to the ORBES portion of a given BEA area. Comparisons also are made between regional energy consumption and energy consumption in the six-state area and the United States.

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## FOREWORD

The Ohio River Basin Energy Study (ORBES) is an interdisciplinary, multi-university inquiry into the environmental, economic, and social impacts of energy facility development in a major portion of the Ohio River Basin. The study was initiated by the U.S. Environmental Protection Agency in 1976 in response to a directive from the U.S. Senate Appropriations Committee.

Most of the ORBES research was conducted by a group of faculty members at the University of Illinois, Indiana University, the University of Kentucky, the University of Louisville, The Ohio State University, the University of Pittsburgh, Purdue University, and West Virginia University. In a few instances, the necessary expertise was found at other universities or independent research organizations.

This report is one of a series produced in support of the overall ORBES assessment. For a summary of the entire study, see Ohio River Basin Energy Study (ORBES): Main Report, by the ORBES Core Team, also being published by the U.S. Environmental Protection Agency.

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## PREFACE

This is a report of research completed on regional energy consumption patterns as of 1974. The study was part of the Ohio River Basin Energy Study (ORBES), funded through the Office of Research and Development, U.S. Environmental Protection Agency. The principal investigator was Walter P. Page, West Virginia University. The work was undertaken at the request of the ORBES Core Team and Project Office, which specified the scope of work and general methodology for performing the calculations.

The author wishes to thank John Gowdy, Mahmood Moghimzadeh, Kyung Hun Lee, and John Uribe for assisting with the calculations of energy consumption patterns. Special thanks are extended to Mary Ann Albertazzie for her competent typing services and cooperative attitude and to the Bureau of Business Research, West Virginia University, for managing the grant.

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(4-76)

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TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

CONTENTS

Preface. . . . . .iv

Figures. . . . . .vi

Tables . . . . . vii

1. Introduction. . . . . 1

2. Work at Oak Ridge National Laboratory . . . . . 4

3. Procedures for Calculating Regional Energy Consumption Tables . . . . . .11

4. Calculation of Regional Energy Consumption Tables . .16

5. Regional, Six-State, and United States Energy Consumption, 1974. . . . . .19

References . . . . . .22

Appendices

A. Energy Consumption by Sector and Fuel Type Tables A-1 to A-9, 1974, and Corresponding Figures A-1 to A-4 . . . . . .23

B. Regional Electricity Exports. . . . . .37

C. BEA Areas Partly and Totally in the ORBES Region. . .42

D. Factors for Allocating ORBES Portions . . . . . .51

BEGIN LAST LINE OF TEXT
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3/8"



PAGE NUMBER
EPA-287 (Clm.)
(4-76)

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TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

## FIGURES


| Number | | Page |
|---|---|---|
| 1 | ORBES Region. . . . . | 2 |
| 2 | Flow Diagram of Fuel Use: Crude Oil. . . . . | 7 |
| 3 | Flow Diagram of Fuel Use: Coal . . . . . | 8 |
| 4 | Flow Diagram of Fuel Use: Hydro-Nuclear, Geothermal, and Solar. . . . . | 9 |
| 5 | Flow Diagram of Fuel Use: Natural Gas. . . . . | 10 |
| 6 | BEA Areas Totally or Partly in the ORBES Region . . . | 13 |
| A-1 | Total Energy Consumed, 1974, by End User for the United States, ORBES Six-State Area, and ORBES Region . . . . . | 33 |
| A-2 | Total Primary Fuels Consumed, 1974, by Fuel for the United States, ORBES Six-State Area, and ORBES Region . . . . . | 34 |
| A-3 | Percent of Total Energy Consumed, 1974, by End User for the United States, ORBES Six-State Area, and ORBES Region . . . . . | 35 |
| A-4 | Percent of Total Primary Fuels Consumed, 1974, by Fuel for the United States, ORBES Six-State Area, and ORBES Region . . . . . | 36 |


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PAGE NUMBER
EPA-287 (Cin.) (4-76)

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CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

TABLES


| Number | | Page |
|---|---|---|
| 1 | Regional Energy Balance Statement by Sector and Fuel Type. . . . . | 6 |
| A-1 | Energy Consumption by Sector and Fuel Type, 1974, United States. . . . . | 24 |
| A-2 | Energy Consumption by Sector and Fuel Type, 1974, ORBES Region . . . . . | 25 |
| A-3 | Energy Consumption by Sector and Fuel Type, 1974, ORBES Six-States . . . . . | 26 |
| A-4 | Energy Consumption by Sector and Fuel Type, 1974, Illinois . . . . . | 27 |
| A-5 | Energy Consumption by Sector and Fuel Type, 1974, Indiana. . . . . | 28 |
| A-6 | Energy Consumption by Sector and Fuel Type, 1974, Kentucky . . . . . | 29 |
| A-7 | Energy Consumption by Sector and Fuel Type, 1974, Ohio . . . . . | 30 |
| A-8 | Energy Consumption by Sector and Fuel Type, 1974, Pennsylvania . . . . . | 31 |
| A-9 | Energy Consumption by Sector and Fuel Type, 1974, West Virginia. . . . . | 32 |
| C-1 | BEA Areas Partly within the ORBES Region. . . . . | 43 |
| C-2 | BEA Areas Totally within the ORBES Region . . . . . | 46 |
| D-1 | Factors for Allocating ORBES Portion of BEA-Region Energy Consumption . . . . . | 52 |
| D-2 | Factors for Allocating ORBES Portion of State Fuel Use for Electric Generation. . . . . | 54 |


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EPA-267 (Cin.) (4-76)

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TOP OF IMAGE AREA
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## TABLES


| Number | | Page |
|---|---|---|
| D-3 | Factors for Allocating ORBES Portion of State Fuel Consumption of Petroleum Products in Refining. . . . . | 55 |
| D-4 | Factors for Allocating ORBES Portion of State Consumption of Natural Gas in Refining. . . . . | 56 |
| D-5 | Factors for Allocating ORBES Portion of State Losses and Omissions by Fuel and Electric Generation. . . . . | 57 |


9 1/2"
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EPA-287 (Cin.)
(4-76)

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# SECTION 1

## INTRODUCTION

The Ohio River Basin Energy Study (ORBES) is charged with assessing "...the potential environmental, social, and economic impacts of the proposed concentration of power plants in the lower Ohio River Basin." Phase II of the study, spanning a two-year period ending October 31, 1979, focuses on a regional analysis consistent with the above mandate. In ORBES Phase II, the study region is defined to include all of Kentucky and portions of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia (see Figure 1). Among technology assessments, the project is unique with respect to its regional focus; the study region is not simply the sum of six states. Regional boundaries for Phase II were determined in such a way as to include (1) desired portions of the Ohio River drainage basin and (2) regional coal fields.

To the same extent that the project is unique among technology assessments, its information and modeling needs also are unique. In particular, alternative regional characteristics for the year 2000 are obtained through use of several scenario and impact models. Alternative futures are generated by altering the conditions (parameters, policies, and so forth) specified as inputs to the scenario models. Thus, evaluation of the environmental, social, and economic impacts associated with these futures requires comprehensive regional baseline data. Among the required sets of baseline data, regional energy consumption data by fuel type and end user are important for an understanding of regional energy characteristics and for purposes of comparing energy and fuel use between the present (1974) and a set of possible futures (2000).

The purpose of this work, then, is to provide two sets of information:

1. Data on energy consumption in the ORBES region by end user and fuel type for the baseline period (1974).

2. Comparisons between regional baseline energy consumption and energy consumption in the six-state area and the United States.

As noted above, the ORBES region boundaries do not correspond to state boundaries. This raises a unique problem with respect to the purposes outlined above because energy consumption data, by fuel type and end user, is not readily available below the state level. Two general approaches are available to estimate substate regional energy consumption information. The first would be to construct a regional energy table by developing a series of regionally based energy-sensitive weights. These weights would be used (1) to allocate state energy consumption data, by fuel type and end user,

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FIGURE I

OHIO RIVER BASIN ENERGY STUDY REGION

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from existing sources to the ORBES portion of each state and (2) to sum across the total and partial states included in the study region. The second approach would be to take advantage of the one existing source of substate energy consumption information, that from Oak Ridge National Laboratory (ORNL) at the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) level (1), and to aggregate across BEA areas for an approximation to the ORBES region. As some BEA areas are only partly within the ORBES region, the latter approach would require a set of "factors" for allocating partial BEA area energy consumption to the ORBES portion of the given BEA area. These two options were presented to the ORBES Core Team and Project Office, which requested the author to provide the above information on regional baseline energy consumption following the second approach. This is a report of that work.

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## SECTION 2

## WORK AT OAK RIDGE NATIONAL LABORATORY

The only consistent source of substate energy consumption data is that prepared at the BEA level by researchers at Oak Ridge National Laboratory. That work, initially funded by the Economic Development Administration, provides both baseline and projected energy balance statements by fuel type and end user for each BEA area in the United States, as well as for several aggregations of BEA areas. In the present work, only the 1974 baseline BEA-area energy consumption data from ORNL are used.

The ORNL procedure for calculating BEA-area baseline energy consumption is to allocate state-level data to county groups, which are then assembled into BEA areas. The allocations by end use for the baseline energy consumption data were based on a series of energy-sensitive weights developed at ORNL. The details of the ORNL procedure, as well as its handling of other components in the energy balance statements, can be found in the relevant ORNL documents (1, 2). To achieve consistency in state-level data sources, ORNL used well-defined and well-documented state-level aggregates from the Bureau of Mines (BOM) (3). The state-level energy consumption aggregates serve as control totals that constrain the level of individual (BEA) disaggregated components. A wide variety of other sources is used to develop energy-sensitive weights for distributing aggregates to the disaggregated components. The baseline data, then, are derived from an accounting procedure where energy-sensitive weights are used to allocate state totals to substate areas, the former serving as control totals.

The ORNL regionalization procedure for calculating baseline BEA area energy consumption was based on two assumptions: (1) for each consuming sector, the primary determinant of the subregion's share in the state's energy consumption is its relative share in the state level of activity in that sector and (2) the effects of spatial differences in energy consumption between states can be measured by an aggregate comparison of state differences in energy use per unit of historic activity (residential, commercial, etc. energy use). Given these assumptions, the procedure consists of three steps: (1) initial estimates of energy demand for each subregion are obtained using the historic patterns of energy use per unit of activity and the regional activity in each sector; (2) subregional estimates are adjusted for consistency with the aggregate consumption totals (state-level totals); and (3) subregional estimates of energy consumption are aggregated to the desired level of spatial and sectoral detail. This provides BEA-area estimates of baseline energy consumption for the 1972-1974 period.

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The ORNL results are presented in tables containing energy balance statements for several spatial units (BEA areas, states, and so forth). As an illustration, our Table 1 reproduces one of the ORNL energy balance statements which forms, in this case, the necessary data for constructing our 1974 United States energy consumption table (Table A-1). Unlike most conventional energy balance tables (e.g., those of BOM), the ORNL tables report energy consumption, production, and transformation in one energy balance statement that gives explicit recognition of the flows into and out of the transformation sectors. The ORNL 1974 data volume (2) provides such tables for all BEA areas in the United States, the 50 individual states, and census regions.

Two unique features of the ORNL energy balance tables deserve comment. First, these tables are unique with respect to the careful handling of the transformation sectors. The tables include more detail than most other energy consumption tables (e.g., those of BOM) and permit careful tracing of flows within the transformation sector to obtain total final consumption and total use of primary fuels. Figures 2-5, are flow charts representing the cycle from primary fuels to intermediate or final consumption of usable energy. In each case, the flows are representative of the data found in the ORNL tables. With respect to crude oil, Figure 2 represents the flow of crude oil to transformation sectors, including nonenergy use of fuels, where refined products are obtained for use in electric generation or directly by end users of refined products. In addition, natural gas liquids are included in this fuel category. Electricity generated from refined products, in turn, flows into the end use sectors as usable energy. In the case of Figure 3, the ORNL procedure is to deal with steam and coking coal all within the fuel category so that there is no transformation flow from the fuel to end user associated with coking. In Figure 4, hydro-nuclear, geothermal, and solar are all included in the fuel box, hydro-nuclear and geothermal flowing to the electric sector while solar flows directly to the residential and commercial sector for space and/or water heat. Natural gas (Figure 5) flows to both the electric sector and transformation processes. Out of the natural gas transformation box, natural gas liquids flow directly back to the crude oil fuel in Figure 2.

The second unique feature of the ORNL tables for BEA energy consumption is the treatment of exports and imports of fuels and energy. The tables are constructed in such a manner that one can aggregate BEA areas to any desired region and intraregional flows will "net out." That is to say, for any aggregate of BEA areas, imports (or, conversely, exports) are net of intraregional flows. This is a particularly important characteristic when constructing regional energy consumption tables that consist of a number of aggregated BEA areas.

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UNITED STATES

# TABLE 1

1974

## REGIONAL ENERGY BALANCE STATEMENT BY SECTOR AND FUEL TYPE

| SECTOR | DISTILLATE OIL | RESIDUAL OIL | GASOLINE | OTHER HYDRO-CARBONS | CRUDE OIL | NATURAL GAS | COAL | ELECTRICITY | SECTOR TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (ALL UNITS IN 10**9 BTU'S) | | | | | | | | | |
| FINAL DEMAND SECTORS | | | | | | | | | | |
| RESIDENTIAL,COMM. | 2,870,295 | 891,224 | - | 2,192,302 | - | 7,083,205 | 297,503 | 3,305,988 | 16,640,517 | 24% |
| INDUSTRIAL | 735,492 | 1,219,606 | - | 1,954,307 | - | 10,018,175 | 4,129,400 | 2,429,620 | 22,486,600 | 32% |
| TRANSPORTATION | 2,121,707 | 709,003 | 12,727,303 | 2,175,605 | - | 604,091 | 2,089 | 14,361 | 18,435,159 | 26% |
| MISCELLANEOUS USES | 59,394 | 214,874 | - | 132,296 | - | 434,382 | - | 84,404 | 925,350 | 1% |
| TOTAL FINAL DEMAND SECTORS | 5,786,888 | 3,034,707 | 12,727,303 | 8,454,510 | - | 18,220,653 | 4,428,992 | 5,834,573 | 58,487,626 | 83% |
| TRANSFORMATION | | | | | | | | | | |
| ELECTRICITY GEN. | 300,052 | 3,032,434 | - | 34,811 | - | 3,500,833 | 8,683,269 | -8,925,362 | 10,626,037 | 15% |
| PETROLEUM PRODUCTS | -5,672,176 | -2,455,021 | -12,261,334 | -6,265,364 | 25,686,613 | 1,098,552 | - | - | 131,270 | 0% |
| NATURAL GAS | - | - | - | -1,411,579 | - | 1,541,279 | - | - | 129,700 | 0% |
| SYN-GAS | - | - | - | - | - | - | - | - | - | |
| NET FUEL USED IN TRANSFORMATION | -5,372,124 | 577,413 | -12,261,334 | -7,642,132 | 25,686,613 | 6,140,664 | 8,683,269 | -8,925,362 | 10,887,007 | 15% |
| TOTAL GROSS FLOWS | 6,086,940 | 6,067,141 | 12,727,303 | 8,489,321 | 25,686,613 | 24,361,317 | 13,112,261 | 5,834,573 | 69,374,633 | 98% |
| LOSSES & OMISSIONS | 177,172 | -36,180 | -80,823 | -574,832 | 234,213 | 439,487 | 533,126 | 569,894 | 1,262,055 | 2% |
| TOTAL NET USAGE | 591,936 | 3,575,939 | 385,145 | 237,545 | 25,920,826 | 24,800,804 | 13,645,387 | 1,479,105 | 70,636,688 | |
| SUPPLY OF ENERGY | | | | | | | | | | |
| FOSSIL FUEL | - | - | - | - | 18,565,956 | 23,781,305 | 15,018,061 | - | 57,365,322 | 98% |
| HYDROELECTRIC | - | - | - | - | - | - | - | 1,037,954 | 1,037,954 | 2% |
| NUCLEAR | - | - | - | - | - | - | - | 388,927 | 388,927 | 1% |
| GEO.&SOLAR | - | - | - | - | - | - | - | 8,902 | 8,902 | 0% |
| TOTAL SUPPLY | - | - | - | - | 18,565,956 | 23,781,305 | 15,018,061 | 1,435,783 | 58,801,105 | |
| NET IMPORTS OF REGION | 591,936 | 3,575,939 | 385,145 | 237,545 | 7,354,870 | 1,019,499 | -1,372,673 | 43,322 | 11,835,583 | |

NOTES:

1 TRANSFORMATION LOSS FOR ELECTRICITY GEN. =68.33%
2 TRANSFORMATION LOSS FOR PETROLEUM PRODUCTS = 0.49%
3 TRANSFORMATION LOSS FOR NATURAL GAS = 8.42%
4 TRANSFORMATION LOSS FOR SYN-GAS = 0.0 %

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**FIGURE 2**
**FLOW DIAGRAM OF FUEL USE: CRUDE OIL**

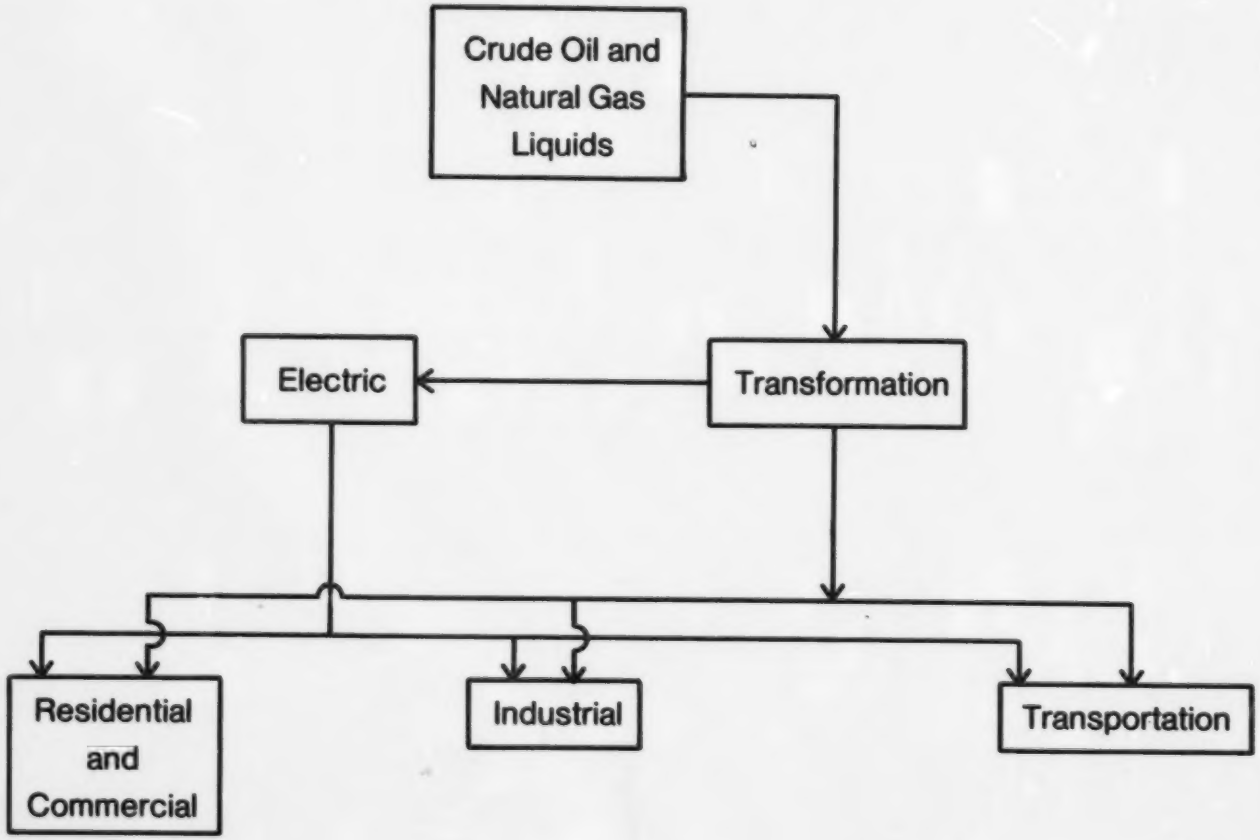


**FIGURE 3**
**FLOW DIAGRAM OF FUEL USE: COAL**

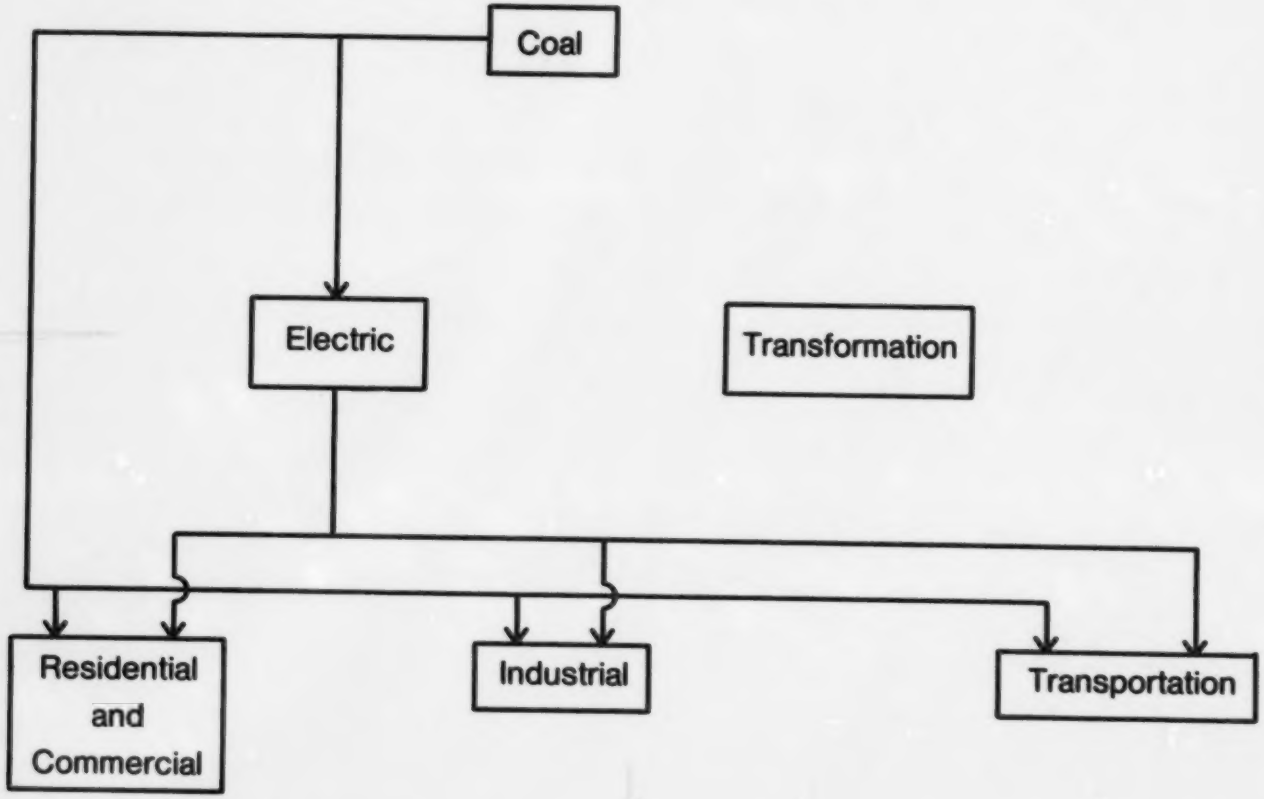


**FIGURE 4**

**FLOW DIAGRAM OF FUEL USE:**
**HYDRO-NUCLEAR, GEOTHERMAL AND SOLAR**

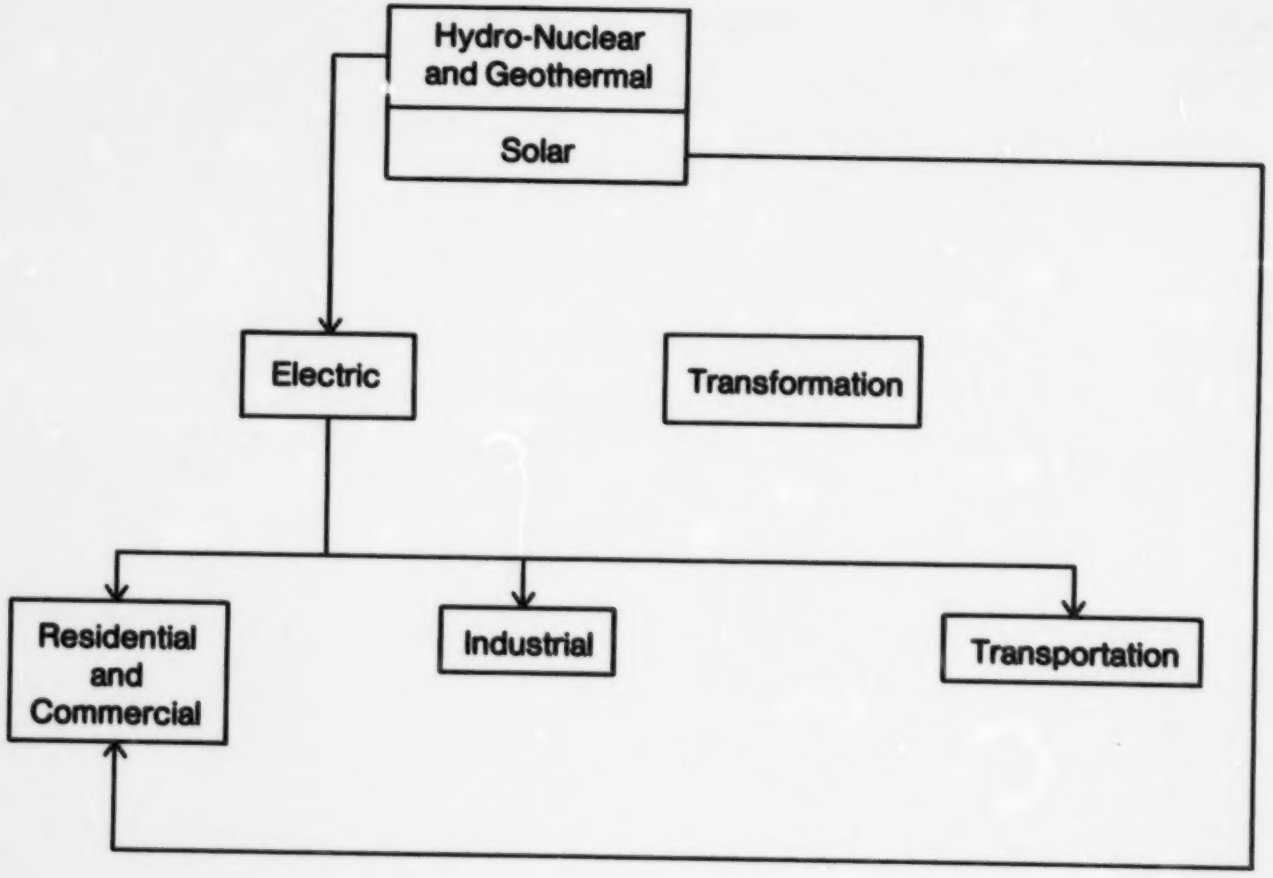
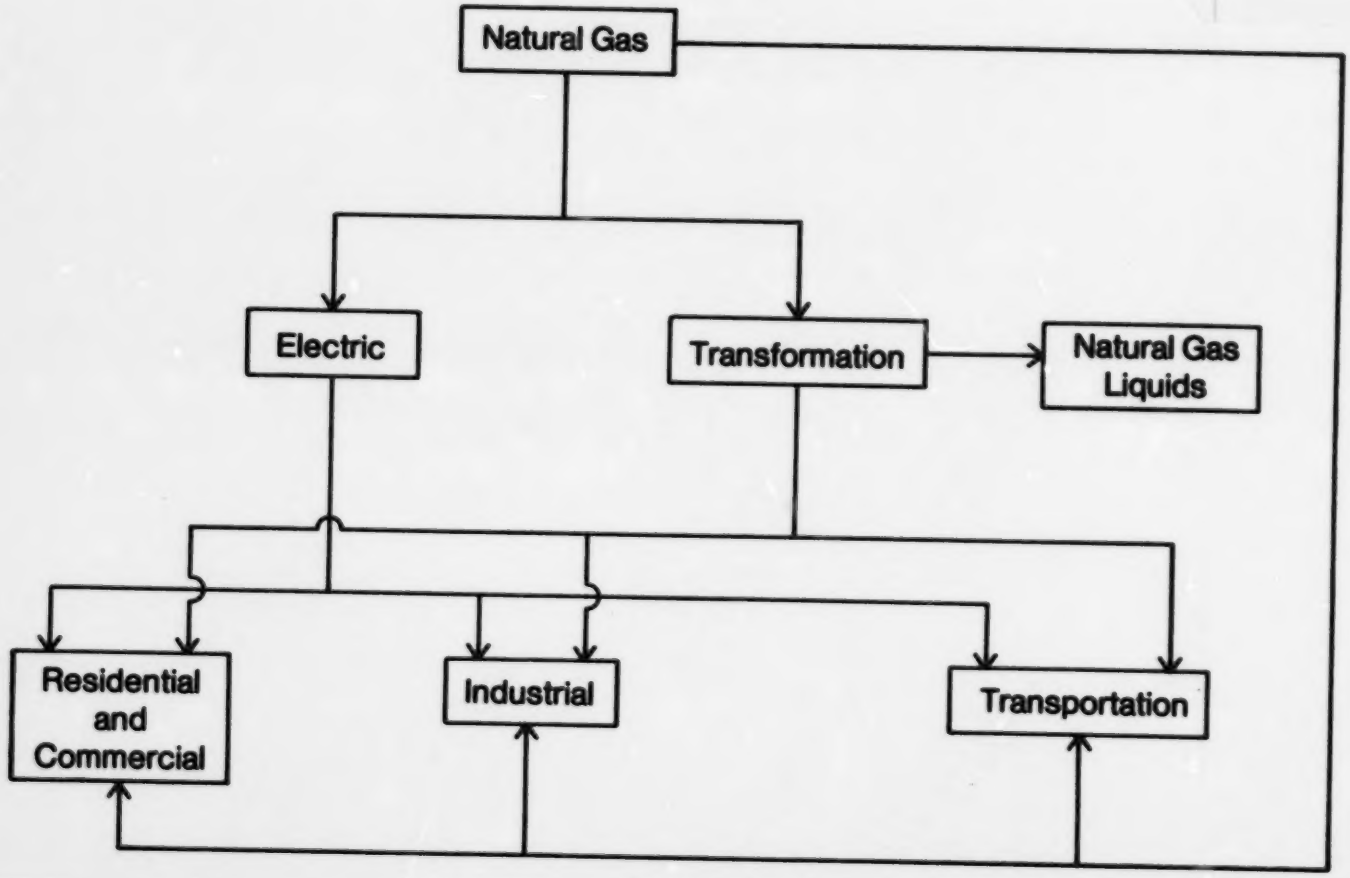


**FIGURE 5**
**FLOW DIAGRAM OF FUEL USE: NATURAL GAS**



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## SECTION 3

## PROCEDURES FOR CALCULATING REGIONAL ENERGY CONSUMPTION TABLES

Using the ORNL tables, four steps are necessary to arrive at estimates of 1974 energy consumption by fuel type and end user in the ORBES region: (1) construct a format for the regional energy consumption tables consistent with the ORNL framework for reporting those data; (2) identify BEA areas totally or partly in the ORBES region and specify counties in each partial BEA that are within the ORBES region; (3) develop a set of appropriate weights for allocating partial BEA-area energy consumption to the counties that lie within the ORBES region; and (4) aggregate energy consumption by fuel type and end user for BEA areas partly or totally within the ORBES region. The procedure is, of course, more straightforward for constructing a table that does not require allocating partial BEA area energy consumption, such as the six-state or United States tables, because steps (2) and (3) above are not necessary.

For baseline information we are interested in knowing, by end use sector, the consumption of fuels (including nonelectric transformation) and of electricity. Further, given the assumed prominent role of electric generation in the ORBES region, we would like detail on the consumption of fuels for electric generation in the region, as well as regional electricity export/import characteristics. While detailed information on particular uses of energy within given end-use sectors would be desirable (e.g., space conditioning versus transportation use in the household sector or materials modification in the industrial sector), the ORNL data tables do not permit this level of detailed analysis. We have used a format for our energy consumption tables similar to that found in BOM end use consumption tables by fuel type. However, our tables also include electric power exports/imports, which can be calculated from the ORNL tables. Further, our format includes the consumption of fuels for nonelectric transformation processes (captured in our "losses and omissions" row--see Appendix A tables).

Within this format, two special characteristics require some explanation. The first relates to handling non-fossil-fuel generation of electricity; the second to the notion of electricity "exports."

In the ORNL tables, as well as in this work, non-fossil-fuel generation of electricity enters into total generation in terms of output units. In many energy consumption tables the convention has been to report non-fossil-fuel generation of electricity in fossil-fuel equivalents. When calculating exports/imports of electricity, however, the use of fossil-fuel equivalents will seriously distort (from conventional values) the estimate of exports/imports. Because this is the case, we choose to follow the same procedure as

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adopted by ORNL; that is, non-fossil-fuel generation of electricity is reported in output units (Btu's).

The second important characteristic of our format concerns the notion of electricity exports. In this case, exports are simply the difference between total electricity generated within the spatial area and the total consumption of electricity in the same area over the relevant time period. Such a calculation does not, of course, represent a "flow" of electricity outside the physical boundaries of a region at any point in time. Rather, it represents an estimate, over the relevant accounting period, of the difference between production and domestic consumption. We have chosen to use an annual accounting period, which is justified in terms of the seasonal component of electricity demand. Further, the estimate of electricity exports will, of course, be sensitive to the geographic boundaries of the region under consideration. Changing the boundary will include or exclude certain generating units and/or consuming sectors in such a way as to alter the estimates of generation and/or consumption and, hence, exports. All one can do is carry out the calculations for the prescribed geographic boundaries and report the associated estimate of electricity exports for those given boundaries. Such a notion of "exports" should not be confused with load management considerations that lead to system sharing. Because electric exports/imports are important to the ORBES project, we include an Appendix B dealing further with this topic.

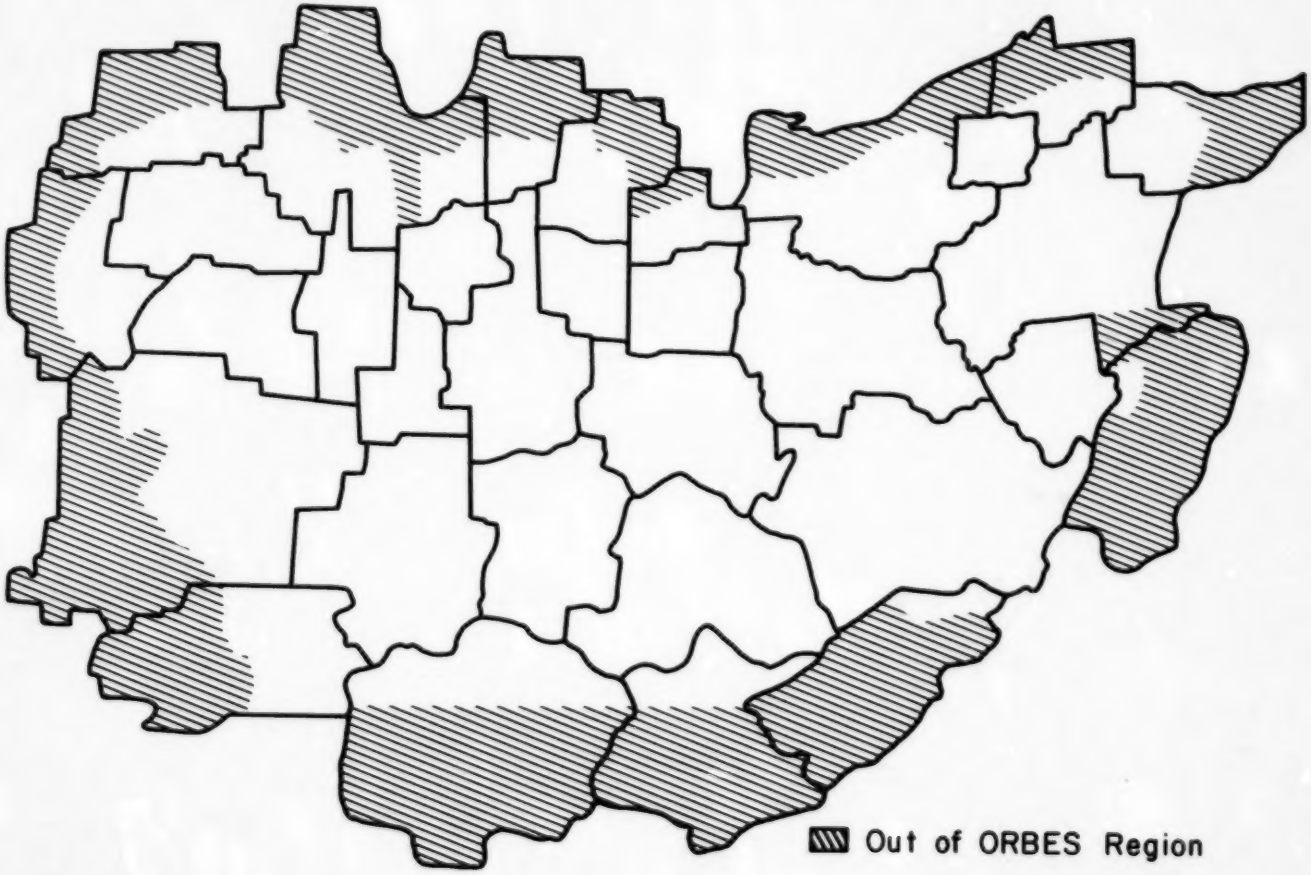
The second step discussed above was the identification of BEA areas totally or partly in the ORBES region and the specification of those counties in each partial BEA that lie within the ORBES region. Figure 6 is an overlay of BEA areas totally or partly within the ORBES boundaries. Slashed areas represent portions of BEA areas that lie outside the ORBES region. Of the 32 BEA areas shown on the map, 16 are totally and 16 partly within the ORBES region. In order to develop the ORBES-region shares for partial BEA areas, it was necessary to identify those counties for each BEA area that are within the ORBES region. Maps of the ORBES region and BEA areas were used, in conjunction with a list of BEA-area counties (4), to prepare a list of ORBES and non-ORBES counties for each BEA area within the region. Appendix C lists counties according to the above dichotomy, relevant BEA number, and state.

Given the information in Appendix C, and the delineation of appropriate BEA areas, it was necessary to develop a set of factors for allocation of total BEA-area energy consumption from the ORNL tables to the ORBES-region portion of a given BEA area by fuel type and end user (step 3 above).

The ORNL energy-sensitive weights represent a sophisticated effort to allocate state totals to BEA areas by specific fuels and users. In reporting the ORNL results for BEA-area consumption, however, certain end user categories are aggregated (residential and commercial, for instance). Thus, it was not possible to apply the same weighting scheme that was used by ORNL. In most cases, however, the factors used here do correspond to the activity variables used by ORNL. As a consequence, the factors reported below seem reasonable, although somewhat crude when compared to the ORNL weighting scheme. Further, the selection of single factors can be justified by the construction of BEA areas, which are comprised of contiguous counties where:

FIGURE 6

BEA AREAS TOTALLY OR PARTLY IN THE ORBES REGION



(1) economic and employment activities are concentrated; and (2) there is a minimum of in/out movement of the working population (see reference 5). Constructed in this way, patterns of energy consumption by end user within a BEA area will be relatively stable and well-defined compared to patterns between BEA areas located either within the same state or in two states.

The allocation of partial BEA-area energy consumption to the ORBES regional share requires calculation of nine different sets of factors, which appear in Appendix D: (1) residential/commercial (Table D-1), (2) industrial (Table D-1), (3) transport (Table D-1), (4) miscellaneous (Table D-1), (5) electric generation use of all fuels (Table D-2), (6) consumption of petroleum products in refining (Table D-3), (7) consumption of natural gas in refining (Table D-4), (8) losses and omissions by fuel (Table D-5), and (9) electric generation (Table D-5).

The first four factors employ activity variables that are determined by those used in the ORNL work. The residential/commercial factors were based on population. For each BEA number, the factor is the ratio of the population in the ORBES counties to the total BEA-area population. Because the ORNL tables do not report the residential and commercial uses of energy separately, it was not possible to develop a weighted factor where employment was the activity variable for the commercial sector and population for the residential sector. Given that a high correlation tends to exist between residential and commercial locations within a given BEA area, population appears to be a reasonable weighting factor for the use of energy in the residential/commercial sector.

Factors for the industrial sector were based on employment in the manufacturing, mining, and construction sectors. Each factor for the industrial use of energy is the ratio of total employment in ORBES counties within the BEA area to total employment for these three sectors in the BEA area. In some cases, to avoid disclosure, mining employment was not reported. In those cases, it appeared that mining output, and hence employment, were relatively small. Where this was not the case, we examined the percentage of total income from manufacturing, mining, and construction in the BEA area associated with mining and found, in most cases, that the percentage was small. As a consequence, the extent of bias introduced by our convention should be similarly small. In the ORNL tables, most nonenergy uses of fuels are included in the industrial sector. Asphalt and a few other hydrocarbons are included in the residential/commercial sector.

The transportation sector includes many heterogenous items (truck and bus--rail and transit--air, water, and pipelines, etc.), and ideally a weighted factor using population for some items and employment for others should be constructed. Time constraints and lack of disaggregated data in the ORNL tables did not permit constructing such an index. The use of employment rather than population is justified as the U.S. Department of Commerce data used for defining the transportation sector includes transportation, communication, and public utilities. The ORNL researchers responsible for this energy consumption work agree that as between just employment or population, employment would be the better single allocating factor for BEA-area fuel use in the transportation sector. This is due largely to the

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fact that transportation fuel use data tend to be recorded at the place of sale (personal communication, David Vogt, ORNL). Each factor, then, is the ratio of employment in the transportation sector of ORBES counties to total employment in transportation in the BEA area.

The allocating factors for miscellaneous consumption of energy are based on the ratio of the population in the ORBES counties to total BEA-area population.

Factors for allocating fuel use in electric generation to the ORBES region were based on the ratio of generation, by fuel type, within ORBES to total generation by fuel type in each state. Because generating units can be identified as in or out of ORBES at the state level, it was not necessary to develop factors for the BEA level and to sum across BEA areas. BEA-area consumption is calculated by ORNL using state totals as controls, and thus no bias is introduced by using state proportions rather than individual BEA-area factors. Consequently, the factors are applied directly to state-level data.

The ORBES-region portion of total state use of petroleum products in refining is based on capacity data in barrels per calendar day or barrels per stream day. Conceptually, the two measures are different, although in one case, the percentages are identical for each state. Again, it is possible to determine the ORBES portion for each state directly without deriving separate BEA-area allocating factors.

For natural gas refining (processing), again, we use the ratio of ORBES capacity to total state capacity.

State factors for total electric generation in the ORBES region were based on the ratio of ORBES-region generating capacity (all fuels) to total state generating capacity (all fuels).

Losses and omissions (largely inventory changes) were allocated to the ORBES region within states according to the average of fuel factors for generating and refining.

Following the above procedures, then, step 4 in the process entails aggregation of the energy data by fuel type and end user to the desired spatial area. In this case, we follow the above procedures to provide 1974 energy consumption tables (see Appendix A). Aggregated data are provided for (1) the United States (Table A-1), (2) the ORBES region (Table A-2), (3) the ORBES six-state area (Table A-3), and (4) individual states totally or partly in the ORBES region (Tables A-4 through A-9). The ORBES six-state and United States energy consumption tables are calculated for purposes of comparison with the ORBES regional energy characteristics (differences in the export of electricity, end use of fuels, etc.). Energy consumption tables for each of the six ORBES states are provided in order that the reader may understand the contribution to six-state energy consumption by each of the individual states. Because this report focuses on ORBES region energy consumption, we do not discuss the individual state tables below.

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## SECTION 4

## CALCULATION OF REGIONAL ENERGY CONSUMPTION TABLES

The aggregation step discussed in Chapter 2 entails relatively complex and tedious calculations. Several assumptions are necessary in the process, with adjustments made to the basic ORNL data to accomodate our own energy consumption table format. As this is the case, we describe below the details of constructing our tables with reference to the basic ORNL data and adjustments made to that data set. The description of calculating procedures is with reference to our United States energy consumption table (Table A-1) using the data from the ORNL United States energy balance statement (Table 1). The reader should refer to Table 1 when reading the following description of calculation procedures.

The calculations described below also apply, of course, to the construction of the ORBES region, ORBES six-state, and individual state energy consumption tables. For the ORBES-region energy consumption table (Table A-2), it was necessary to apply the factors discussed above (Table D-1 through D-5) to the energy consumption for each BEA area (Tables C-1 and C-2) prior to aggregating for the regional table. Total and partial BEA-area data were then summed for the appropriate entry in the regional table. For the individual state energy consumption tables (Tables A-4 to A-9), direct use was made of the individual state energy balance statements from the 1974 ORNL document. For the ORBES six-state total energy consumption data (Table A-3), appropriate sums were taken from the individual state tables.

Coal consumption for residential/commercial, industrial, transportation, miscellaneous, electric power, and losses and omissions in our United States table (Table A-1) is taken directly from the ORNL table (Table 1). The sum over these entries, then, represents the total estimated consumption of coal in 1974 for all uses: final demand, transformation processes, and inventory changes (losses and omissions).

Calculations for all petroleum products required first summing over distillate oil, residual oil, gasoline, and other hydrocarbons in the ORNL table. These data for final demand sectors, petroleum products, are taken directly from Table 1. Similarly, the sum for petroleum products used in electric generation is taken from that table. The refining and electric generation sectors use energy in one form but provide it in another for final consumption. Because this is the case, the total energy use in the transformation sector equals the conversion losses in the transformation process; this is treated as part of final regional demand. In the ORNL table a positive number represents input to the transformation process; a negative number, the output of the process. To calculate our losses and omissions for

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petroleum products, we took the sum of losses and omissions over the four petroleum products in the ORNL table (preserving signs) added losses and omissions from the crude oil column, and added the transformation losses from the petorleum product row of the transformation sector in the ORNL table. The latter figure is the "sector total" for the petroleum products row. The losses and omissions figure in our table, then, includes all these elements. The sum of final demand sectors, electric power use of petroleum products, and losses and omissions (including refining losses) represents the total estimated 1974 consumption of petroleum products. By following this procedure, it is not necessary to include a separate entry for crude oil in the table. In our ORBES regional table, specific fuels used in electric generation were determined by the proportion of a state's total generation within the ORBES region for each fuel (Table D-2).

In Table A-1, natural gas use is handled in the same manner as coal with respect to the final demand sectors and electric generation (read directly from the ORNL table), but losses and omissions are the sum of natural gas losses and omissions plus the transformation loss in refining (processing), which is read from the "sector total" of the natural gas row in the transformation sector. Losses and omissions in natural gas, like petroleum products, include the transformation losses in refining as part of regional total consumption. The sum of final demand sectors, electric generation use of natural gas, and losses and omissions (including processing losses) represents the total consumption of natural gas. Again, in our ORBES regional table, specific fuels used in electric generation were determined by the proportion of state total generation within the ORBES region for each fuel (Table D-2).

Hydro/nuclear in Table A-1 is obtained from the appropriate entries in the "supply of energy" portion of the ORNL table; it is reported in Btu's of output. This column is labeled hydro/nuclear because, other than a trivial amount in Ohio, there is essentially no other non-fossil-fuel generation of electricity in the region.

The total primary fuels column in Table A-1 is the row sum for each defined sector. Signs must be preserved in the summing process.

For distributed electricity in the final demand sectors of Table A-1, the data were taken directly from the ORNL table but adjusted upward to account for transmission losses. That is to say, the transmission losses were inputs to the individual final demand sectors. A factor of 1.0977 was applied to each entry in the final demand sectors, distributed electricity, of the ORNL table; this value is the national ratio for 1974 of losses and omissions in the electricity row in the ORNL table to total final demand for electricity in the same table. The same adjusting factor was used for all our energy consumption tables. Proceeding in this manner does slightly overestimate the total losses and omissions data from the ORNL tables (by 144 in the case of the United States--570,038 as compared to 569,894), but it has the virtue of allocating the associated transmission losses to specific end user. The difference in results between our estimated net imports and that of ORNL, however, is trivial. The "electric power" figure under distributed electricity in Table A-1 represents total generation; it was calculated as

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electric generation (negative sign) from the ORNL table (electricity generation row, electricity column), to which is added the negative of hydro/nuclear, geothermal, and solar production of electricity. Although no geothermal and solar are reported for the ORBES region (except a trivial amount in Ohio), there is a relatively small amount for the United States, which has been included in the calculations for our national table of energy consumption. There are no losses and omissions in the distributed electricity column; they have already been allocated to the final demand sectors.

The total energy input column in Table A-1 is the horizontal sum of the total primary fuels column and the distributed electricity column. In the case of the electric power row, the sum of total primary fuels and distributed electricity (total generation with negative sign) represents waste heat.

The "grand total" in our energy consumption tables represents an estimate of the total amount of energy consumed during 1974 in the relevant geographical boundaries for each table. It is obtained as the vertical sum down the total energy input column. Aside from the imputed transmission losses to the final demand sectors in the distributed electricity calculations, our "grand total" will roughly correspond to the "total net usage/sector total" figure in the ORNL tables. That is, our figure is net of waste heat and consequently is less than the total primary fuel figure. In each case, for reasons discussed above, our total will be somewhat larger (substantially less than 1%) than the corresponding ORNL total net usage.

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Our row labeled "total final consumption" appears only for purposes of calculating the net import figure for electricity in our table. Net imports (if negative, exports) is the difference between the total final demand for distributed electricity and total generation (electric power row, distributed electricity column). The percentage column, of course, is simply the ratio of total energy input to the grand total figure for each sector. As noted earlier, exports of electricity should not be interpreted as a flow but rather as a point estimate of the difference between generation and consumption over the relevant accounting period (see Appendix B).

The "total consumption, primary fuels" row is the column sum over each fuel of total final consumption, electric power, and losses and omissions. The percentage row represents the percentage each fuel is of the total primary fuels figure.

Following the above calculating procedures, our tables report, for different spatial definitions, energy consumption by designated fuel types and end-use sectors as well as imports/exports of electricity, grand totals of all energy consumed, and total primary fuels. For purposes of comparison, we also calculated two percentages: (1) relative to the "grand total" of energy consumption, the percentage associated with each defined sector and (2) relative to the total use of primary fuels, the percentage associated with each particular fuel.

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## SECTION 5

### REGIONAL, SIX-STATE, AND UNITED STATES ENERGY CONSUMPTION, 1974

Table A-2 reports energy consumption in 1974 for the ORBES region, while Tables A-1 and A-3 report, respectively, the United States and ORBES six-state area energy consumption for the same year. Tables A-4 to A-9 report the individual state energy consumption data. Figures A-1 and A-2 provide graphic presentations of total energy consumed and total primary fuels consumed, respectively, in the ORBES region, the six-state area, and the United States. Figure A-1 is by end user, while A-2 is by fuel type. Figure A-3 is a graphic representation of the percentage of total energy consumed for each geographic area by end-use category, while A-4 contains graphic materials on the percentage each primary fuel is of total primary fuels used in each geographic area. The following discussion of results is in terms of Tables A-1, A-2, A-3 and Figures A-1 to A-4.

While various details of the results reported here may be of interest to different readers, several points are particularly important to the ORBES project. These points are discussed below; the interpretation of other reported results is left to the reader.

A marked difference is evident between total energy consumed during 1974 in the ORBES region and the six-state area. An examination of Figure A-1 (or Tables A-2 and A-3) reveals that total energy consumed in the ORBES region by final demand sector and the total final demand for energy is everywhere approximately 50% of that consumed in the six-state area. With regard to total energy consumed in electric power, however, regional consumption is approximately 77% of the six-state area total. In total energy consumed, then, the ORBES region tends to use relatively more in electric power than does the six-state area (the region uses approximately 50% fewer quads in toto but only 23% fewer quads in electric generation).

Figure A-3 (and Tables A-1, A-2, and A-3) further supports the above conclusions and adds additional insights into comparative energy consumption. While the percent of total energy consumed by individual final demand sectors is everywhere less in the ORBES region than in the six-state area (except in the miscellaneous sector, where they are the same), in the case of electric power use of total energy the percentage in the ORBES region is substantially greater than in the six-state area (24% compared to 18%). The percentage difference is even greater between the ORBES-region use of total energy for electric power and that of the United States (24% as compared to 15%). Relative to both the United States and six-state area, then, the ORBES region has a greater concentration of total energy use in electric power generation.

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The data on primary fuels consumed in each area reveal several other features of regional energy consumption that reinforce the above conclusions. As shown in Figure A-2 (and Tables A-1, A-2, and A-3), except for coal, the amount of primary fuels used in the ORBES region is approximately 50% of that used in the six-state area. In the case of coal, the region uses approximately 72% of that used in the six-state area. Further, as seen in Tables A-1, A-2, and A-3, the percentage of total primary fuels used in all final demand sectors is less for the ORBES region than for the six-state area or the United States: the ORBES region uses 64% of total primary fuels in all final demand sectors while the six-state area uses 71% and the United States 75%. Said differently, the ORBES region uses approximately 34% of total primary fuels for electric generation compared to 24% and 27% for, respectively, the United States and the six-state area (losses and omissions bring these totals to 100%). As was true of total energy consumption, then, the ORBES regional pattern of primary fuel consumption is dramatically different from that of the six-state area or the United States: the region uses approximately 50% as much primary fuels as the six-state area except for coal where it uses 72% as much, and primary fuel use in the region is more concentrated in electric production than is true of the six-state area or the United States.

These results suggest, of course, that coal plays a prominent role in the region relative to the six-state area and the United States and, moreover, helps account, in part, for the relative specialization of the region in electric power production. Figure A-4 shows that coal accounts for approximately 49% of total primary fuels in the ORBES region but only 40% in the six-state area and 19% in the United States. Further, as seen in Tables A-1, A-2, and A-3, coal constitutes approximately 95% of total primary fuel use in electric generation in the ORBES region compared to 90% and 51% for, respectively, the ORBES six states and the United States. For industrial use of total primary fuels, coal constitutes approximately 48% and 21% for, respectively, the ORBES six states and the United States. Clearly, relative to the six-state area and the United States, the ORBES region makes heavy use of coal as a primary fuel.

The distribution of total coal used in the ORBES region reflects the relative concentration of its use in electric power generation: 67% of total coal used in the ORBES region is for electric power generation, compared to 60% and 64% for the six-state area and the United States, respectively.

The conclusion regarding coal, then, is quite clear: the ORBES region uses a substantially greater percentage of coal as a primary fuel than either the United States or the six-state area, and coal use in electric generation for the region constitutes a higher percentage, by end user, of coal than is true for the United States or the six-state area. This characteristic of coal use in the region is further supported by the data on total energy use depicted in Figures A-1 and A-3.

The above discussion of electric generation makes clear that, relative to the United States and the six-state area, the ORBES region is specialized in the use of total energy and total primary fuels for the production of

electricity. Tables A-1, A-2, and A-3 further reveal the extent to which the region is a net exporter of electricity. In the ORBES region, net imports are -276,357 (exports), compared to -112,450 for the six-state area and +43,469 for the United States (imports). It should be noted that the method of calculating energy consumption for different spatial regions does not tell us, of course, whether the exported electricity is going to non-ORBES areas within the six states or to other states. Nonetheless, we can determine the extent to which the ORBES region is export-oriented relative to the six-state area and the United States. From our tables, the ORBES regional exports of electricity are 246% of the six-state total exports of electricity, while total ORBES-region generation is only 69% of generation in the six-state area. Another way to view the matter is to note that 93% of electricity generated in the six-state area is used locally, while only 74% of that generated in the ORBES region is used locally.

The conclusion regarding electric consumption and export, then, is quite clear: relative to the six-state area, the ORBES region is specialized in the generation of electricity and is heavily oriented toward the export of electricity.

Of some interest also is the relative role of hydro/nuclear, geothermal, and solar in the three spatial regions. With reference to Figures A-2 and A-4, non-fossil fuels play a conspicuously smaller role in the ORBES region than in the six-state area or the United States. In terms of percentage use of total primary fuels, the United States, six-state area, and ORBES region uses of non-fossil fuels are 2%, 1%, and 0% (36,827 X $10^9$ Btu's), respectively.

This work, then, supports the following general conclusions:

1. The ORBES-region consumption of total energy and primary fuels is dramatically different from that of the six-state area.

2. Relative to the six-state area and the United States, the ORBES region is highly specialized in electric production and the export of electricity.

3. Relative to uses of primary fuels in the six-state area and the United States, the ORBES region is more oriented toward (1) the use of primary fuels for electric generation and (2) the use of coal as a primary fuel.

4. Within the ORBES region, non-fossil fuels play an insignificant role when compared to their use in the six-state area and the United States. In all cases, the percentage of total primary fuels associated with non-fossil fuels is very small (the maximum is 2% for the United States).

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# APPENDIX A

## ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE TABLES A-1 TO A-9, 1974, AND CORRESPONDING FIGURES A-1 TO A-4



PAGE NUMBER
EPA-287 (Cin.)
(4-76)

TABLE A-1

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, UNITED STATES

(all units $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 297,503 | 5,953,821 | 7,083,205 | - | 13,334,529 | 3,628,983 | 16,963,512 | 24 |
| Industrial | 4,129,400 | 5,909,405 | 10,018,175 | - | 20,056,980 | 2,666,994 | 22,723,974 | 32 |
| Transportation | 2,089 | 17,733,618 | 684,891 | - | 18,420,598 | 15,984 | 18,436,582 | 26 |
| Miscellaneous | - | 406,564 | 434,382 | - | 840,946 | 92,650 | 933,596 | 1 |
| Total Final Consumption | 4,428,992 | 30,003,408 | 18,220,653 | - | 52,653,053 | 6,404,611 | 59,057,664 | 84 |
| Electric Power | 8,683,269 | 3,367,297 | 3,500,833 | 1,435,783 | 16,987,179 | -6,361,142≠ | 10,626,037≠ | 15 |
| Losses & Omissions | 533,126 | -149,180 | 569,187 | - | 953,133 | 0 | 953,133 | 1 |
| Total Consumption Primary Fuels | 13,645,387 | 33,221,525 | 22,290,673 | 1,435,783 | 70,593,365 | NET IMPORTS | - | 43,469 |
| Percentage§ | 19 | 47 | 32 | 2 | - | GRAND TOTAL (NET) | - | 70,636,834 |

NOTE: Transformation loss for electric generation = 68.33%
Transformation loss for petroleum products = 0.49%
Transformation loss for natural gas = 8.42%
Transformation loss for synthetic gas = 0.00%

* Percentage of grand total
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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TABLE A-2
ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, ORBES REGION
(all units in $10^9$ Btu's)

| Source/Sector | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 62,687 | 577,391 | 1,070,768 | - | 1,710,846 | 375,959 | 2,086,805 | 21 |
| Industrial | 1,368,807 | 618,754 | 867,748 | - | 2,855,309 | 420,375 | 3,275,684 | 33 |
| Transportation | 217 | 1,752,561 | 73,742 | - | 1,826,520 | 1,649 | 1,828,169 | 18 |
| Miscellaneous | - | 34,227 | 55,171 | - | 89,398 | 7,203 | 96,601 | 1 |
| Total Final Consumption | 1,431,711 | 2,982,933 | 2,067,429 | - | 6,482,073 | 805,186 | 7,287,259 | 73 |
| Electric Power | 3,316,566 | 86,768 | 41,444 | 36,827 | 3,481,605 | -1,081,543≠ | 2,400,062≠ | 24 |
| Losses & Omissions | 213,518 | -18,033 | 46,333 | - | 241,818 | 0 | 241,818 | 3 |
| Total Consumption Primary Fuels | 4,961,795 | 3,051,668 | 2,155,206 | 36,827 | 10,205,496 | NET IMPORTS - -276,357 | | |
| Percentage§ | 49 | 30 | 21 | 0 | - | GRAND TOTAL (NET) - 9,929,139 | | |

NOTE: Transformation loss for electric generation = 68.55% (weighted average of six-state transformation losses)

* Percentage of grand total
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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TABLE A-3

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, ORBES SIX STATES

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 106,795 | 1,177,488 | 2,072,422 | - | 3,356,705 | 694,959 | 4,051,664 | 24 |
| Industrial | 2,415,479 | 1,366,200 | 1,607,644 | - | 5,389,323 | 738,592 | 6,127,915 | 36 |
| Transportation | 445 | 3,341,810 | 110,321 | - | 3,452,576 | 4,797 | 3,457,373 | 20 |
| Miscellaneous | 0 | 75,392 | 87,791 | - | 163,183 | 12,952 | 176,135 | 1 |
| Total Final Consumption | 2,522,719 | 5,960,890 | 3,878,178 | - | 12,361,787 | 1,451,300 | 13,813,087 | 80 |
| Electric Power | 4,148,052 | 280,060 | 91,773 | 113,006 | 4,632,891 | -1,563,750≠ | 3,069,141≠ | 18 |
| Losses & Omissions | 271,220 | -30,986 | 81,364 | - | 321,598 | 0 | 321,598 | 2 |
| Total Consumption Primary Fuels | 6,941,991 | 6,209,964 | 4,051,315 | 113,006 | 17,316,276 | | | |
| Percentage§ | 40 | 36 | 23 | 1 | - | | | |

| | | |
|---|---|---|
| NET IMPORTS | - | -112,450 |
| GRAND TOTAL (NET) | - | 17,203,826 |

NOTE: Transformation losses for each individual state used in calculation. See Tables C-3 to C-8

* Percentage of grand total
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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TABLE A-4

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, ILLINOIS

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 24,896 | 315,083 | 666,121 | - | 1,006,100 | 179,000 | 1,185,100 | 31 |
| Industrial | 198,698 | 369,488 | 413,783 | - | 981,969 | 124,536 | 1,106,505 | 29 |
| Transportation | 127 | 915,174 | 19,621 | - | 934,922 | 1,200 | 936,122 | 24 |
| Miscellaneous | - | 29,153 | 27,139 | - | 56,292 | 5,945 | 62,237 | 2 |
| Total Final Consumption | 223,721 | 1,628,898 | 1,126,644 | - | 2,979,283 | 310,681 | 3,289,964 | 85 |
| Electric Power | 671,652 | 72,196 | 43,590 | 67,228 | 854,666 | -312,601≠ | 542,065≠ | 14 |
| Losses & Omissions | 36,404 | -7,257 | 24,960 | - | 54,107 | 0 | 54,107 | 1 |
| Total Consumption Primary Fuels | 931,777 | 1,693,837 | 1,195,214 | 67,228 | 3,888,056 | NET IMPORTS | - | -1,920 |
| Percentage§ | 24 | 44 | 31 | 2 | - | GRAND TOTAL (NET) | - | 3,886,136 |

NOTE: Transformation loss for electric generation = 68.84%
Transformation loss for petroleum products = 0.42%
Transformation loss for natural gas = 8.42%
Transformation loss for synthetic gas = 0.00%

* Percentage of grand total
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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TABLE A-5

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, INDIANA

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 12,684 | 222,696 | 228,362 | - | 463,742 | 85,570 | 549,312 | 22 |
| Industrial | 439,151 | 192,290 | 268,262 | - | 899,703 | 90,501 | 990,204 | 40 |
| Transportation | 47 | 438,738 | 12,845 | - | 451,630 | 100 | 451,730 | 18 |
| Miscellaneous | - | 16,216 | 11,093 | - | 27,309 | 206 | 27,515 | 1 |
| Total Final Consumption | 451,882 | 869,940 | 520,562 | - | 1,842,384 | 176,377 | 2,018,761 | 82 |
| Electric Power | 542,806 | 16,707 | 14,251 | 1,518 | 575,282 | -190,229≠ | 385,053≠ | 16 |
| Losses & Omissions | 40,442 | 1,235 | 10,347 | - | 52,024 | 0 | 52,024 | 2 |
| Total Consumption Primary Fuels | 1,035,130 | 887,882 | 545,160 | 1,518 | 2,469,690 | NET IMPORTS | - | -13,852 |
| Percentage§ | 42 | 36 | 22 | 0 | - | GRAND TOTAL (NET) | - | 2,455,838 |

NOTE: Transformation loss for electric generation = 67.11%
Transformation loss for petroleum products = 0.62%
Transformation loss for natural gas = 0.00%
Transformation loss for synthetic gas = 0.00%

* Percentage
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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TABLE A-6

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, KENTUCKY

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 9,008 | 55,843 | 111,645 | - | 176,496 | 65,365 | 241,861 | 20 |
| Industrial | 94,579 | 65,787 | 79,277 | - | 239,643 | 95,632 | 335,275 | 27 |
| Transportation | 30 | 267,167 | 30,027 | - | 297,224 | - | 297,224 | 24 |
| Miscellaneous | - | 2,666 | 9,608 | - | 12,274 | 2,903 | 15,177 | 1 |
| Total Final Consumption | 103,617 | 391,463 | 230,557 | - | 725,637 | 163,900 | 889,537 | 72 |
| Electric Power | 480,535 | 1,258 | 5,578 | 11,596 | 498,967 | -176,073≠ | 322,894≠ | 26 |
| Losses & Omissions | 23,750 | -2,643 | 5,828 | - | 26,935 | 0 | 26,935 | 2 |
| Total Consumption Primary Fuels | 607,902 | 390,078 | 241,963 | 11,596 | 1,251,539 | NET IMPORTS | - | -12,173 |
| Percentage§ | 49 | 31 | 19 | 1 | - | GRAND TOTAL (NET) | - | 1,239,366 |

NOTE: Transformation loss for electric generation = 66.25%
Transformation loss for petroleum products = 0.56%
Transformation loss for natural gas = 8.42%
Transformation loss for synthetic gas = 0.00%

* Percentage
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

TABLE A-7

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, OHIO

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 34,859 | 195,995 | 619,804 | - | 850,658 | 175,115 | 1,025,773 | 24 |
| Industrial | 630,122 | 272,332 | 433,532 | - | 1,335,986 | 219,344 | 1,555,330 | 37 |
| Transportation | 102 | 772,939 | 10,295 | - | 783,336 | 100 | 783,436 | 19 |
| Miscellaneous | - | 6,964 | 22,818 | - | 29,782 | 3,433 | 33,215 | 1 |
| Total Final Consumption | 665,083 | 1,248,230 | 1,086,449 | - | 2,999,762 | 397,992 | 3,397,754 | 81 |
| Electric Power | 1,010,180 | 38,992 | 19,980 | 44 | 1,069,196 | -335,114≠ | 734,082≠ | 17 |
| Losses & Omissions | 68,113 | -11,909 | 20,760 | - | 76,964 | 0 | 76,964 | 2 |
| Total Consumption Primary Fuels | 1,743,376 | 1,275,313 | 1,127,189 | 44 | 4,145,922 | NET IMPORTS | - | 62,878 |
| Percentage§ | 42 | 31 | 27 | 0 | - | GRAND TOTAL (NET) | - | 4,208,800 |

NOTE: Transformation loss for electric generation = 68.66%
Transformation loss for petroleum products = 0.12%
Transformation loss for natural gas = 0.00%
Transformation loss for synthetic gas = 0.00%

* Percentage
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

TABLE A-8

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, PENNSYLVANIA

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 15,364 | 374,354 | 370,658 | - | 760,376 | 162,753 | 923,129 | 22 |
| Industrial | 797,411 | 374,682 | 301,906 | - | 1,473,999 | 170,904 | 1,644,903 | 39 |
| Transportation | 120 | 820,770 | 21,515 | - | 842,405 | 3,397 | 845,802 | 20 |
| Miscellaneous | - | 19,332 | 12,776 | - | 32,108 | 426 | 32,534 | 1 |
| Total Final Consumption | 812,895 | 1,589,138 | 706,855 | - | 3,108,888 | 337,480 | 3,446,368 | 82 |
| Electric Power | 844,218 | 143,491 | 7,989 | 30,993 | 1,026,691 | -339,830≠ | 686,861≠ | 16 |
| Losses & Omissions | 67,375 | -4,572 | 13,862 | - | 76,665 | 0 | 76,665 | 2 |
| Total Consumption Primary Fuels | 1,724,488 | 1,728,057 | 728,806 | 30,993 | 4,212,244 | NET IMPORTS | - | -2,350 |
| Percentage§ | 41 | 41 | 17 | 1 | - | GRAND TOTAL (NET) | - | 4,209,894 |

NOTE: Transformation loss for electric generation = 68.98%
Transformation loss for petroleum products = 0.26%
Transformation loss for natural gas = 8.70%
Transformation loss for synthetic gas = 0.00%

* Percentage of grand total
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

TABLE A-9

ENERGY CONSUMPTION BY SECTOR AND FUEL TYPE, 1974, WEST VIRGINIA

(all units in $10^9$ Btu's)

| Sector/Source | Coal | Petroleum Product | Natural Gas | Hydro/ Nuclear | Total Primary Fuels | Distributed Electricity | Total Energy Input | Percentage* |
|---|---|---|---|---|---|---|---|---|
| Residential & Commercial | 9,984 | 13,517 | 75,832 | - | 99,333 | 27,157 | 126,490 | 11 |
| Industrial | 255,518 | 91,621 | 110,884 | - | 458,023 | 37,675 | 495,698 | 41 |
| Transportation | 19 | 127,022 | 16,018 | - | 143,059 | - | 143,059 | 12 |
| Miscellaneous | - | 1,061 | 4,357 | - | 5,418 | 38 | 5,456 | 0 |
| Total Final Consumption | 265,521 | 233,221 | 207,091 | - | 705,833 | 64,870 | 770,703 | 64 |
| Electric Power | 598,661 | 7,416 | 385 | 1,627 | 608,089 | -209,903≠ | 398,186≠ | 33 |
| Losses & Omissions | 35,136 | -5,840 | 5,607 | - | 34,903 | 0 | 34,903 | 3 |
| Total Consumption Primary Fuels | 899,318 | 234,797 | 213,083 | 1,627 | 1,348,825 | NET IMPORTS | - | -145,033 |
| | | | | | | GRAND TOTALS (NET) | - | 1,203,792 |
| Percentage§ | 67 | 17 | 16 | 0 | - | | | |

NOTE: Transformation loss for electric generation = 65.66%
Transformation loss for petroleum products = 0.53%
Transformation loss for natural gas = 8.42%
Transformation loss for syntehtic gas = 0.00%

* Percentage
≠ Total generation
≠ Waste heat
§ Percentage of total consumption, primary fuels

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FIGURE A-1

TOTAL ENERGY CONSUMED, 1974, BY END USER FOR THE UNITED STATES, ORBES SIX-STATE AREA, AND ORBES REGION

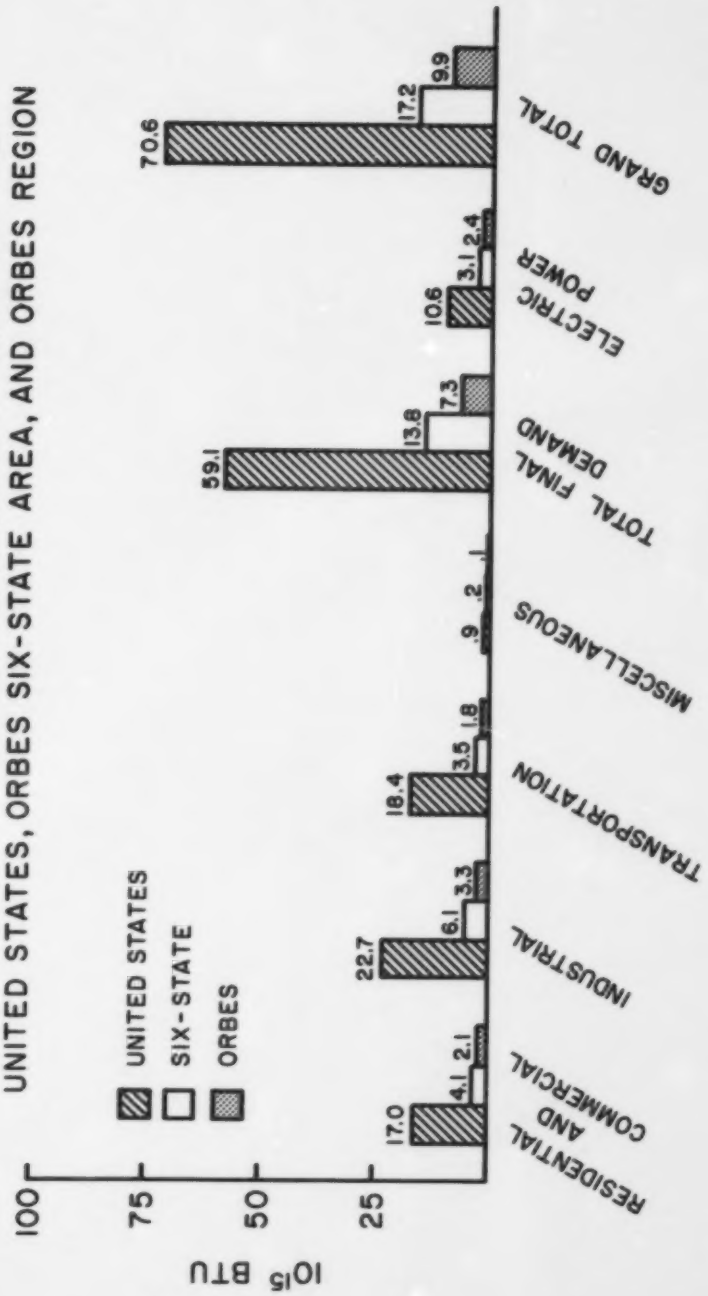

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FIGURE A-2

TOTAL PRIMARY FUELS CONSUMED, 1974, BY FUEL FOR THE UNITED STATES, ORBES SIX-STATE AREA, AND ORBES REGION

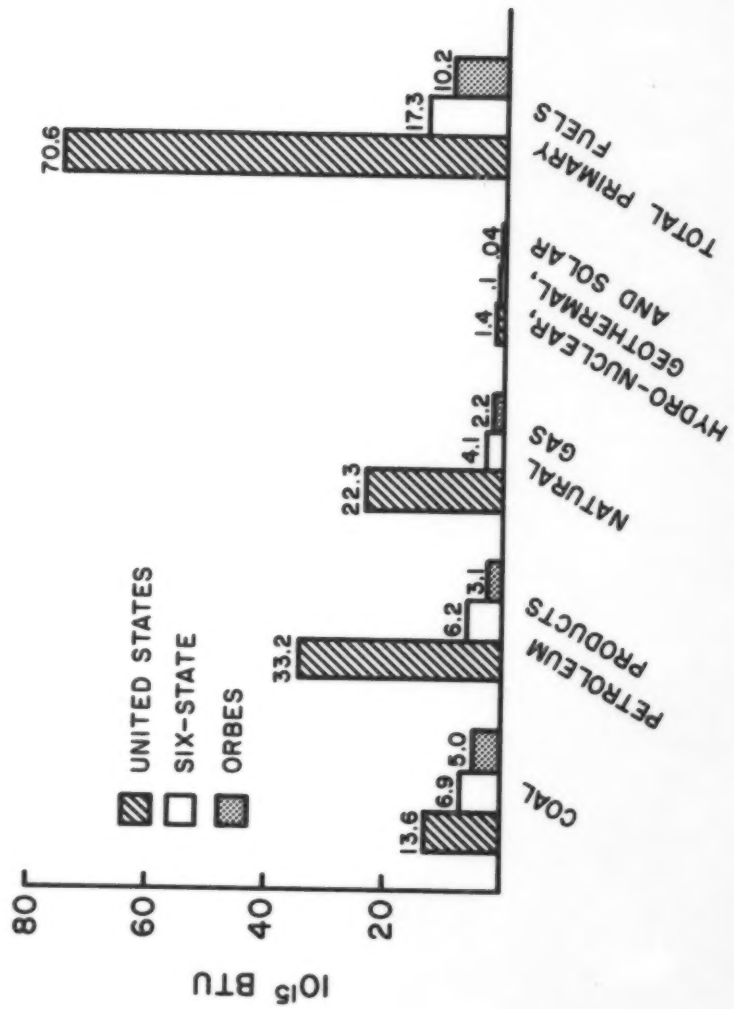


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FIGURE A-3

PERCENT OF TOTAL ENERGY CONSUMED, 1974, BY END USER FOR THE UNITED STATES, ORBES SIX-STATE AREA, AND ORBES REGION

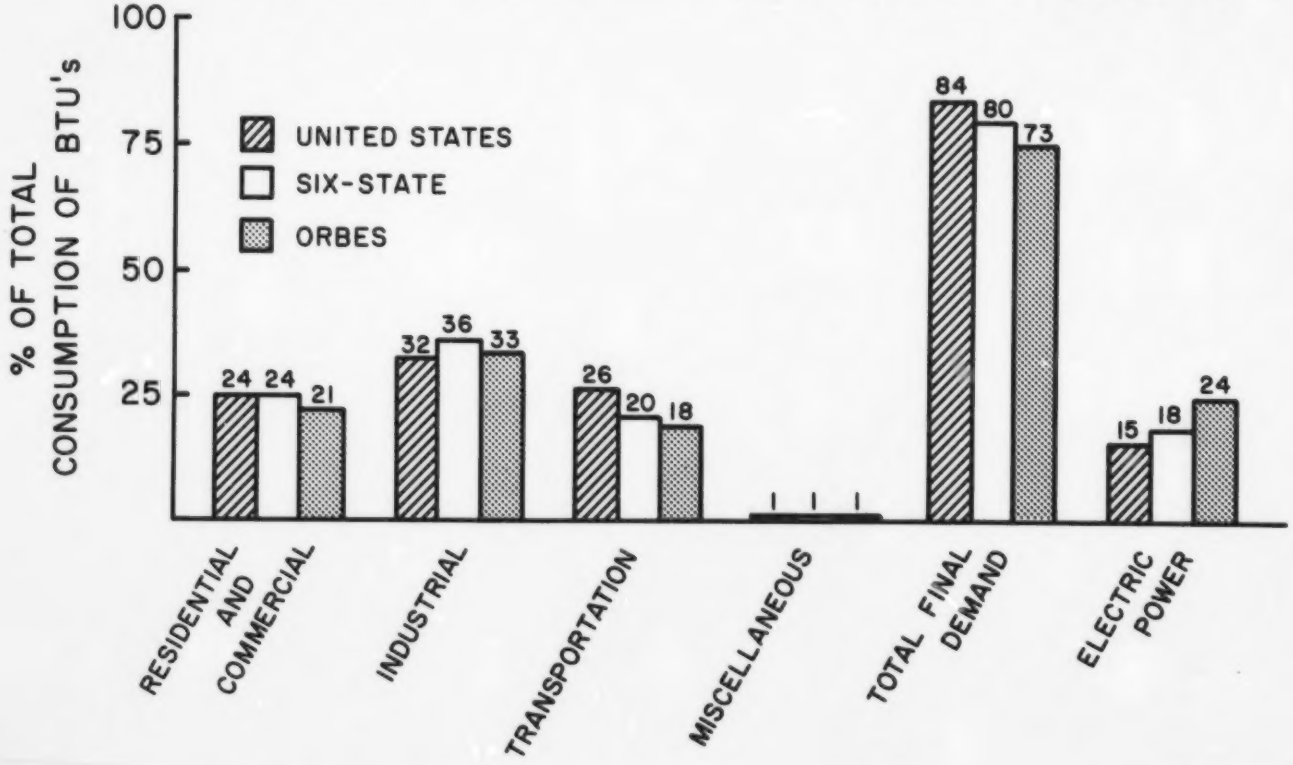

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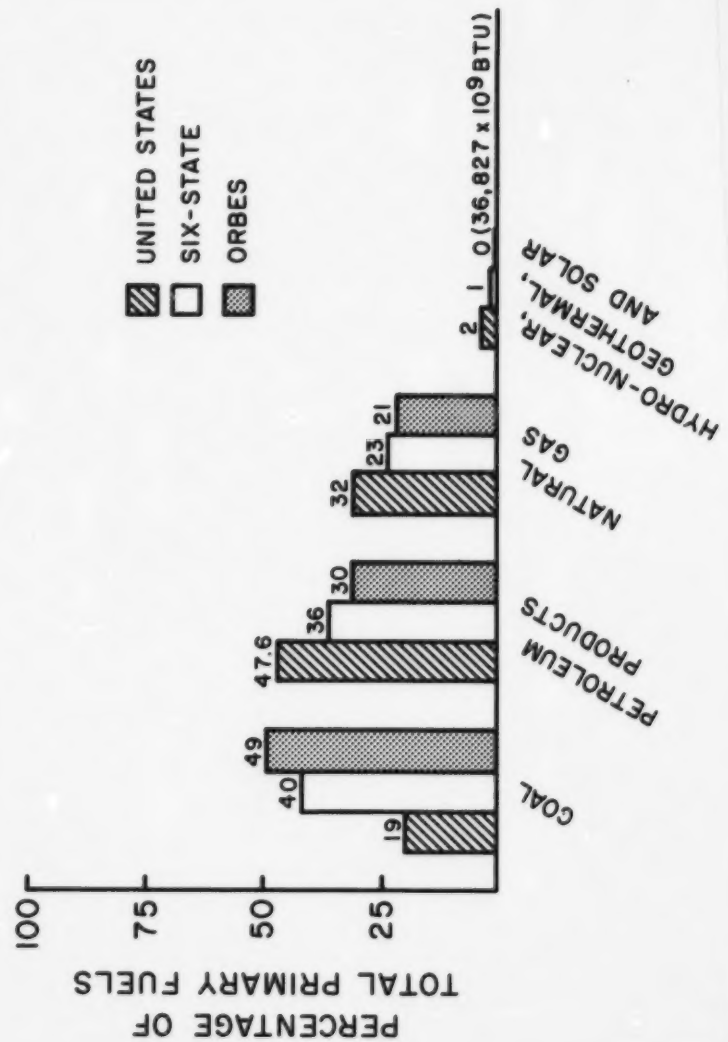
FIGURE A-4

PERCENT OF TOTAL PRIMARY FUELS CONSUMED, 1974, BY FUEL FOR THE UNITED STATES, ORBES SIX-STATE AREA, AND ORBES REGION

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**APPENDIX B**

**REGIONAL ELECTRICITY EXPORTS**

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## APPENDIX B

## REGIONAL ELECTRICITY EXPORTS

In this report, electricity exports are the difference between the estimated annual consumption of electricity in the region and the total annual generation of electricity by plants within the region. The purpose of drawing a distinction between annual domestic and export consumption of electricity is to provide a comparison between the 1974 situation reported in the text and year 2000 domestic and export electric demand characteristics from the output of the ORBES regional fuel and energy demand model. Further, the split between domestic and export consumption of electricity generated in the region, 1974, is an important piece of input information to the specification of parameters in the regional demand model. The notion of electricity exports, then, used in this report is based on the difference between "stock" variables over an annual period rather than "flow" variables. Hence, the estimate of ORBES electricity exports, 1974, in the text does not suggest that magnitude is realized in any particular day, week, or month, but rather over the year that amount is exported from the region.

Load management considerations by a given generating company reflect "flow" considerations at a point in time where time tends to be dichotomized with respect to baseload and peaking requirements. Conceptually, a generating company perceives of a specific service area it attempts to satisfy with respect to estimated baseload and peaking requirements (it estimates a load curve). These are only estimates and generation/load will not necessarily be in balance at any specific point in time. Consequently, purchases and sales of electricity take place between the given company and others in order to correct for any over or underestimation at a point in time. Such transfers, from the point of view of a given company, would constitute exports or imports of electricity relative to the geographic boundaries of the service area. Similarly, exports or imports of electricity for a larger geographic area than a company service area, say a reliability council area, would be estimated by aggregating over the companies within the reliability council area. Such estimates could be performed for any time period desired (daily, weekly, etc.). These estimates would rely upon knowledge of company service areas and intercompany sales of electricity over the relevant time period. If the exercise were performed for a specified region over a one year period, say the ORBES Phase II boundaries, the estimate of electricity exports should roughly correspond to that derived by the procedure used in this report.

As noted in the text of this report, the calculation of 1974 ORBES region (Phase II boundaries), electricity consumption by end user and fuel type is handled with a fairly elaborate estimating procedure. Generation is

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estimated with a more straightforward procedure, again outlined in the text. The results of those calculations (Table A-2) reveal that approximately 26.5% of electricity generated in the ORBES region, 1974, was exported outside of the region. Calculations performed by staff members of ECAR and reported to this author in a letter from Mr. Owen Lentz, Executive Manager of ECAR, dated April 16, 1979, estimates electricity exports from the ORBES region, 1974, at 26.6% of generation. The calculations performed by Mr. Lentz and his staff represent, of course, the second approach outlined above. There exists, then, a very close degree of correspondence between the two estimates, each following different approaches to calculating regional electricity exports. One has confidence, therefore, in the electric sector estimates reported in this text.

There exists, however, two conceptual matters concerning electricity exports which require further discussion. These are: (1) the sensitivity of electricity exports to the selection of geographical boundaries and (2) the relationship of electricity exports to the distribution of social costs from power generation.

As generating units and service areas can be located spatially, clearly the specification of a regional boundary will be an important determinant of the estimated export of electricity. During the ORBES project, electricity exports have been calculated for three different regional boundaries; Phase I and II boundaries as well as the area approximately either side of the Ohio River from Pittsburgh to the extreme southern tip of Illinois. Phase I boundaries are identical to Phase II (see Figure 1 in text) except Pennsylvania and West Virginia were not included in Phase I. The region from Pittsburgh to the extreme tip of Illinois along the Ohio was examined as an area approximating the present and proposed concentration of power plants along the Ohio River. The present writer provided calculations of electricity exports for the ORBES Phase II boundary and the Ohio River boundary while Mr. Lentz of ECAR provided calculations for Phase I and Phase II boundaries (letter dated April 16, 1979). For convenience, these estimates and the designation of geographical boundaries are presented below.

Estimates of Electricity Exports with Alternative Boundaries

| Boundary | ECAR (Lentz) | Page |
|---|---|---|
| ORBES Phase II | 26.6% | 26.5% |
| ORBES Phase I | 14.3% | none |
| Ohio River | none | 41% |

As noted earlier, the Phase II electricity export calculations performed by Mr. Lentz's office and those reported here are almost identical. The Phase I boundary calculation performed by Mr. Lentz shows a lesser degree of specialization in electricity export. In large measure this is due to the addition of the West Virginia electric sector for the Phase II boundaries, as West Virginia is a major exporter of electricity. Such an addition, in this writer's view, is justified in terms of the project mandate from Congress. A similar justification can be made for the addition of southwestern

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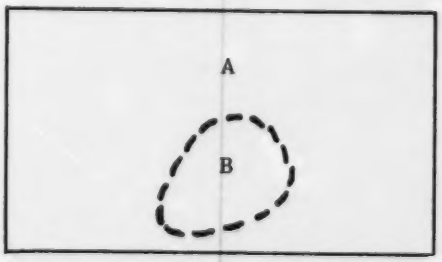
Pennsylvania to the study area in Phase II. In terms of potential impacts from power development, the addition of West Virginia to the study regions seems necessary in order to examine the implications for regional coal use associated with power developments. The Ohio River boundary calculation noted above represents a much higher percentage of electricity exported than either Phase I or Phase II boundaries. This is due, of course, to the boundary capturing the present concentration of power plants along the Ohio River. Much of what is generated in that area (41%) is exported to centers of economic activity away from the river.

The purpose of the above discussion, then, is to clarify the sensitivity of electric export calculations to the selection of geographic boundaries. The point, of course, is quite clear: The closer the boundary corresponds to concentrated power plants, the greater tends to be the estimate of electricity exports for a given year. As to the selection of the boundaries for Phase II of the project, several criterion were employed and discussed by the Core Team and Advisory Committee. Among other criteria for final selection of the boundaries, inclusion of the Interior and Appalachian coal reserves, exclusion of areas bordering on the Great Lakes and relative economic homogeneity appear to have been important. The selected boundary appears to be a reasonable compromise on those criteria and was selected with input from both the Core Team and Advisory Committee of ORBES. Given that boundary, Mr. Lentz's calculations correspond extremely well to those of the present writer.

The final matter requiring discussion concerns the relationship between electricity exports and the distribution of social costs from power generation. This issue goes to the original discussion leading to funding of the ORBES project. That is to say, what is the justification for arguing that the proposed concentration of power plants in the Ohio River Drainage Basin constitutes a social economic and/or political issue of sufficient magnitude to undertake the present project? Further, of what significance are electricity exports to that concern?

The characteristic of the problem is the difference between private costs (the producer's perspective) and the distribution and magnitude of full social costs (the perspective of organized citizens such as Save the Valley). To illustrate the point, assume the area (A) formed by the solid line in the figure below is some arbitrary geographic service area for electricity while the dashed subarea (B) represents a concentration of power plants to service the load requirements throughout the entire region A. The utilities, focusing on private cost minimization subject to system integrity, site



feasibility and other decision rules, argue that the concentration of plants within area B is justified. Organized citizens, however, may argue as follows: (1) The environmental quality within B is substantially deteriorated because of residuals associated with generation and, as a consequence, the human, etc. impacts from power production are heavily concentrated in B and (2) there may be region-wide (throughout A) impacts associated with generation and transmission over long distances of residuals which effect the health and well-being of the entire population in the region A. To the extent that there are substantial exports of electricity from corridor B, those living in B believe they have even stronger arguments related to localized impacts and the distribution of health and other costs of servicing total demands in A (they must bear an inordinate amount of the social costs associated with electric demands substantial distances from them). The utilities, as a regulated industry, are focusing attention on the private (legally defined) costs of servicing electric demand in region A while concerned citizens are looking to the social costs associated with power production, both the total social costs to the area and what they perceive to be the unequal distribution of those costs (concentrated in area B). Both perspectives are legitimate, although one represents a less comprehensive notion of costs (utilities) than the other (concerned citizens) in the sense that full social costs from power production are not considered in the former.

The above discussion is relevant only to the extent that environmental emissions (liquid, gaseous or solid residuals emitted into the environment) do indeed entail human "costs" in the form of health damages, reductions in agricultural productivity, etc. which are not internally calculated as a private (legal) cost by producers. The object of the present project is to estimate the magnitude and concentration of these costs (impacts) to citizens of the Ohio Valley or to those in areas removed from the Valley but exposed to environmental deterioration due to long-range transport of pollutants. These estimates are made under a variety of hypothetical or plausable future conditions.

To the extent, then, that the ORBES region is export oriented with respect to electricity, there may be a concentration of these social costs within the region and the charge of ORBES researchers is to estimate those costs. The calculation of the electricity export nature of the region serves as an index (comparatively speaking) of the potential magnitude of these social costs. Viewed differently, the electric export characteristics of the region serves implicitly as a parameter for the extent to which the citizens of the Ohio Valley bear social costs for servicing the electric demand loads outside of the region. Electricity exports, then, are analytically important in examining regional impacts associated with energy and fuel developments in the Ohio River Valley.

APPENDIX C

BEA AREAS PARTLY AND TOTALLY IN THE ORBES REGION

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# APPENDIX C

## BEA AREAS PARTLY AND TOTALLY IN THE ORBES REGION

### TABLE C-1

### BEA AREAS PARTLY WITHIN THE ORBES REGION

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 10 | PA: Venango, Forest | PA: Erie, Crawford, Warren |
| 11 | PA: Elk, Jefferson, Clearfield | PA: Centre, Cameron, Clinton, Lycoming, Sullivan |
| 19 | WV: Grant | WV: Pendleton, Hardy, Hampshire, Morgan, Berkeley, Jefferson |
| | | VA: Bath, Rockbridge, Augusta, Rockingham, Page, Shenandoah, Warren, Clarke, Frederick, Highland, Buena Vista*, Harrisonburg, Lexington*, Staunton*, Waynesboro*, Winchester* |
| 49 | KY: Trigg, Christian, Todd, Logan, Butler, Warren, Simpson, Allen, Monroe, Cumberland, Metcalfe, Barren, Edmonson, Clinton | TN: Stewart, Houston, Benton, Perry, Lewis, Lawrence, Giles, Marshall, Moore, Bedford, Coffee, Warren, Van Buren, White, Putnam, Wilson, Robertson, Montgomery, Dickson, Overton, Pickett, Clay, Macon, Sumner, Davidson, Cheatham, Hickman, Humphreys, Maury, Williamson, Rutherford, Cannon, Dekalb, Smith, Jackson, Trousdale |

*Independent cities

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TABLE C-1 (continued)

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 50 | KY: Wayne, McCreary, Whitley, Bell, Knox, Harlan, Laurel | TN: Claiborne, Grainger, Hamblen, Jefferson, Cocke, Sevier, Blount, Knox, Anderson, Monroe, Loudon, Morgan, Roane, Fentress, Cumberland, Scott, Campbell, Union |
| 51 | WV: McDowell, Mercer | TN: Hancock, Hawkins, Sullivan, Carter, Johnson, Unicoi, Washington, Greene |
| | | VA: Buchanan, Bland, Dickenson, Lee, Russell, Smyth, Tazewell, Norton, Wise, Washington, Scott, Bristol*, |
| 66 | WV: Hancock, Brooke, Ohio, Marshall, Tyler, Wetzel | WV: Mineral |
| | OH: Monroe, Belmont, Harrison, Jefferson | MD: Allegany, Garrett |
| | PA: Clairon, Armstrong, Indiana, Cambria, Somerset, Westmoreland, Fayette, Greene, Washington, Allegheny, Butler, Beaver | |
| 68 | OH: Wyandot, Crawford, Richland, Ashland, Morrow, Knox, Coshocton, Tuscarawas, Carroll, Holmes, Wayne, Stark, Portage, Columbiana, Summit, Medina | OH: Erie, Huron, Lake, Lorain, Cuyahoga, Geauga, Ashtabula |
| 69 | OH: Mercer, Allen, Auglaize, Hardin | OH: Putnam, Van Wert |

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TABLE C-1 (continued)

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 75 | IN: Noble, Allen, Whitley, Adams, Wells, Huntington, Wabash | IN: Steuben, Dekalb |
| | | OH: Williams, Defiance, Paulding |
| 76 | IN: Fulton, Marshall, Kosciusko | IN: St. Joseph, Elkhart, Lagrange |
| | | MI: Berrien, Cass, St. Joseph |
| 77 | IL: La Salle, Grundy Putnam, Livingston, Iroquois, Kankakee | IL: Kendall, Cook, Dekalb, Kane, DuPage, McHenry, Lake, Will |
| | IN: Jasper, Pulaski, Starke | IN: LaPorte, Porter, Lake, Newton |
| 79 | IL: Mercer, Henry, Bureau | IL: Rock Island, Whiteside, Carroll |
| | | IA: Clinton, Scott, Muscatine, Louisa |
| 113 | IL: Henderson, Hancock, Adams, Schuyler, Brown, Pike | IA: Lee, Henry, Des Moines |
| | | MO: Clark, Lewis, Marion, Ralls |
| 114 | IL: Calhoun, Greene, Jersey, Madison, Bond, Macoupin, Montgomery, Fayette, Effingham, Jasper, Richland, St. Clair, Clinton, Marion, Clay, Wayne, Jefferson, Washington, Monroe, Randolph, Perry, Franklin, Jackson, Williamson | MO: St. Louis, St. Louis City, Franklin, Jefferson, St. Charles, Pike, Lincoln, Montgomery, Warren, Gasconade, Maries, Pulaski, Laclede, Texas, Dent, Reynolds, Iron, Madison, Perry, St. Francois, St. Genevieve, Washington, Crawford, Phelps |

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TABLE C-1 (continued)

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 115 | IL: Union, Johnson, Pope, Hardin, Massac, Pulaski, Alexander | MO: Carter, Ripley, Wayne, Bollinger, Butler, Cape Girardeau, Scott, Stoddard, Mississippi, New Madrid, Pemiscot, Dunklin |
| | KY: Livingston, Lyon, Marshall, Calloway, Graves, Fulton, Hickman, Carlisle, Ballard, McCracken | TN: Obion, Lake |

TABLE C-2

BEA AREAS TOTALLY WITHIN THE ORBES REGION

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 52 | OH: Meigs, Gallia, Lawrence, Scioto | |
| | WV: Jackson, Roane, Calhoun, Gilmer, Braxton, Webster, Pocahontas, Nicholas, Clay, Kanawha, Putnam, Mason, Cabell, Lincoln, Wayne, Boone, Logan, Mingo, Wyoming, Raleigh, Summers, Monroe, Greenbrier, Fayette | |
| | KY: Greenup, Boyd, Carter, Rowan, Elliott, Lawrence, Johnson, Martin, Floyd, Pike | |

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TABLE C-2 (continued)

| BEA Number | | ORBES Counties | Non-ORBES Counties |
|---|---|---|---|
| 53 | KY: | Russel, Adair, Green, Taylor, Casey, Pulaski, Rockcastle, Lincoln, Boyle, Mercer, Anderson, Franklin, Scott, Woodford, Jessamine, Garrard, Madison, Fayette, Bourbon, Clark, Harrison, Nicholas, Bath, Montgomery, Powell, Menifee, Morgan, Magoffin, Wolfe, Breathitt, Lee, Estill, Jackson, Clay, Leslie, Perry, Letcher, Owsley, Knott | |
| 54 | IN: | Orange, Crawford, Harrison, Floyd, Clark, Scott, Jefferson, Washington | |
| | KY: | Trimble, Henry, Oldham, Shelby, Jefferson, Bullitt, Spencer, Hardin, Grayson, Hart, Breckinridge, Larue, Marion, Washington, Nelson, Meade | |
| 55 | IL: | Saline, Gallatin, Hamilton, White, Edwards, Wabash, Lawrence | |
| | IN: | Knox, Daviess, Martin, Gibson, Pike, Dubois, Posey, Perry, Spencer, Warrick, Vanderburgh | |

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TABLE C-2 (continued)

| BEA Number | | ORBES Counties | Non-ORBES Counties |
|---|---|---|---|
| 55 | KY: | Hancock, Daviess, Henderson, Union, Crittenden, Webster, Hopkins, Caldwell, Muhlenberg, Ohio, McLean | |
| 56 | IL: | Crawford, Clark | |
| | IN: | Vigo, Clay, Greene, Sullivan, Parke, Vermilion | |
| 57 | IL: | Mason, Logan, DeWitt, Cass, Menard, Sangamon, Morgan, Scott, Christian, Shelby, Moultrie, Macon | |
| 58 | IL: | Ford, Piatt, Champaign, Vermillion, Douglas, Edgar, Coles, Cumberland | |
| 59 | IN: | White, Benton, Carroll, Clinton, Tippecanoe, Montgomery, Fountain, Warren | |
| 60 | IN: | Lawrence, Jackson, Jennings, Monroe, Brown, Bartholomew, Decatur, Rush, Shelby, Johnson, Morgan, Owen, Putnam, Hendricks, Marion, Hancock, Hamilton, Boone, Tipton, Howard, Cass, Miami | |
| 61 | IN: | Wayne, Henry, Randolph, Delaware, Madison, Jay, Blackford, Grant | |

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TABLE C-2 (continued)

| BEA Number | | ORBES Counties | Non-ORBES Counties |
|---|---|---|---|
| 62 | IN: | Switzerland, Ohio, Dearborn, Ripley, Franklin, Fayette, Union | |
| | OH: | Butler, Warren, Clinton, Hamilton, Clermont, Brown, Adams, Highland | |
| | KY: | Boone, Kenton, Campbell, Gallatin, Carroll, Owen, Grant, Pendleton, Bracken, Robertson, Mason, Lewis, Fleming | |
| 63 | OH: | Logan, Shelby, Darke, Miami, Clark, Champaign, Greene, Montgomery, Preble | |
| 64 | OH: | Marion, Union, Deleware, Licking, Franklin, Madison, Pickaway, Fayette, Ross, Pike, Jackson, Vinton, Hocking, Fairfield, Perry, Muskingum, Morgan, Athens, Washington, Noble, Guernsey | |
| | WV: | Wood, Pleasants, Ritchie, Wirt | |
| 65 | WV: | Monongalia, Marion, Taylor, Preston, Tucker, Randolph, Barbour, Upshur, Lewis, Harrison, Doddridge | |

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TABLE C-2 (continued)

| BEA Number | ORBES Counties | Non-ORBES Counties |
|---|---|---|
| 67 | OH: Trumbull, Mahoning | |
| | PA: Mercer, Lawrence | |
| 78 | IL: Warren, Knox, Stark, Marshall, Woodford, McLean, Tazewell, Fulton, McDonough, Peoria | |

## APPENDIX D

## FACTORS FOR ALLOCATING ORBES PORTIONS

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## APPENDIX D

## FACTORS FOR ALLOCATING ORBES PORTIONS

### TABLE D-1

### FACTORS FOR ALLOCATING ORBES PORTION OF BEA-REGION ENERGY CONSUMPTION

| BEA Number | Residential/Commercial[1] | Industrial[2] | Transport[3] | Miscellaneous[1] |
|---|---|---|---|---|
| 114 | 0.34 | 0.29 | 0.28 | 0.34 |
| 115 | 0.44 | 0.42 | 0.52 | 0.44 |
| 49 | 0.19 | 0.30 | 0.40 | 0.19 |
| 77 | 0.04 | 0.04 | 0.03 | 0.04 |
| 76 | 0.14 | 0.14 | 0.14 | 0.14 |
| 10 | 0.14 | 0.11 | 0.17 | 0.14 |
| 19 | 0.02 | 0.02 | 0.02 | 0.03 |
| 11 | 0.37 | 0.40 | 0.47 | 0.37 |
| 69 | 0.78 | 0.82 | 0.86 | 0.78 |
| 75 | 0.76 | 0.78 | 0.85 | 0.76 |
| 79 | 0.18 | 0.09 | 0.13 | 0.18 |
| 68 | 0.43 | 0.42 | 0.36 | 0.43 |
| 50 | 0.19 | 0.15 | 0.18 | 0.19 |
| 51 | 0.14 | 0.10 | 0.14 | 0.14 |
| 66 | 0.96 | 0.99 | 0.96 | 0.96 |
| 113 | 0.45 | 0.50 | 0.38 | 0.45 |
| 52 | 1.00 | 1.00 | 1.00 | 1.00 |
| 53 | 1.00 | 1.00 | 1.00 | 1.00 |
| 54 | 1.00 | 1.00 | 1.00 | 1.00 |
| 55 | 1.00 | 1.00 | 1.00 | 1.00 |
| 56 | 1.00 | 1.00 | 1.00 | 1.00 |
| 57 | 1.00 | 1.00 | 1.00 | 1.00 |
| 58 | 1.00 | 1.00 | 1.00 | 1.00 |
| 59 | 1.00 | 1.00 | 1.00 | 1.00 |
| 60 | 1.00 | 1.00 | 1.00 | 1.00 |

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TABLE D-1 (continued)

| BEA Number | Residential/Commercial[1] | Industrial[2] | Transport[3] | Miscellaneous[1] |
|---|---|---|---|---|
| 61 | 1.00 | 1.00 | 1.00 | 1.00 |
| 62 | 1.00 | 1.00 | 1.00 | 1.00 |
| 63 | 1.00 | 1.00 | 1.00 | 1.00 |
| 64 | 1.00 | 1.00 | 1.00 | 1.00 |
| 65 | 1.00 | 1.00 | 1.00 | 1.00 |
| 67 | 1.00 | 1.00 | 1.00 | 1.00 |
| 78 | 1.00 | 1.00 | 1.00 | 1.00 |

1. Factors calculated as ratio of ORBES county population in a given BEA region population. County population data for 1974 are taken from Current Population Reports, Series P-26, U.S. Department of Commerce, Bureau of Census, Washington, D.C.

2. Factors calculated as ratio of ORBES county employment in manufacturing, mining, and construction to total BEA region employment in same sectors. County employment data for 1974 are taken from Employment by Type and Broad Industrial Sources, 1974-75, Regional Economic Information System, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C., for appropriate states. In a large number of cases county mining employment was not disclosed for the states used in the calculations, although mining employment data was reported in the state total. We assumed a value of "0" when mining employment for counties was not disclosed.

3. Factors calculated as in column 3 (according to employment) for the transportation sector. In the Bureau of Economic Analysis data source cited above, the sector is defined as including transportation, communication, and public utilities. In the employment data, Grant County employment in transportation was not disclosed. We used the same factor as for the industrial sector.

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TABLE D-2

FACTORS FOR ALLOCATING ORBES PORTION OF STATE FUEL USE FOR ELECTRIC GENERATION[1]

| Fuel | IL | IN | KY | OH | PA | WV |
|---|---|---|---|---|---|---|
| Petroleum products | 0.37 | 0.72 | 1.00 | 0.57 | 0.12 | 1.00 |
| Natural gas | 0.25 | 0.35 | 1.00 | 1.00 | 0.00 | none |
| Coal | 0.67 | 0.79 | 1.00 | 0.81 | 0.64 | 1.00 |
| Hydro-electric | 0.18 | 0.88 | 1.00 | 1.00 | 0.02 | 0.97 |
| Nuclear | 0.33 | none | none | none | 0.00 | none |

1. Factors based on proportion of state totals generated within the ORBES region. Calculations were made using 1976 data from Electrical Generating Unit Inventory, 1976-1986, by Steven D. Jansen, Energy Resources Center, University of Illinois at Chicago Circle, Chicago, Illinois (November 1978).

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(4-76)

TABLE D-3

FACTORS FOR ALLOCATING ORBES PORTION OF STATE FUEL CONSUMPTION OF PETROLEUM PRODUCTS IN REFINING [3]

| | Total Capacity | | ORBES | | Factors (2/1) | |
|---|---|---|---|---|---|---|
| | b/cd[1] | b/sd[2] | b/cd | b/sd | b/cd | b/sd |
| Illinois | 1,181,550 | 1,251,105 | 712,050 | 746,369 | $\frac{712,050}{1,181,550} = 0.60$ 60% | $\frac{746,369}{1,251,105} = 0.60$ 60% |
| Indiana | 561,650 | 592,947 | 70,650 | 72,947 | $\frac{70,650}{561,650} = 0.13$ 13% | $\frac{72,947}{592,947} = 0.12$ 12% |
| Kentucky | 164,470 | 170,500 | 164,470 | 170,500 | 100% | 100% |
| Ohio | 589,950 | 615,000 | 274,700 | 287,000 | $\frac{274,700}{589,950} = 0.47$ 47% | $\frac{287,000}{615,000} = 0.47$ 47% |
| Pennsylvania | 804,920 | 846,415 | 22,220 | 23,115 | $\frac{22,220}{804,920} = 0.03$ 3% | $\frac{23,115}{846,415} = 0.03$ 3% |
| West Virginia | 19,450 | 20,200 | 19,450 | 20,200 | 100% | 100% |

1. b/cd is barrels per calendar day.
2. b/sd is barrels per stream day.
3. Calculated from data in Oil and Gas Journal, March 28, 1977, pp. 97-123.

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TABLE D-4

FACTORS FOR ALLOCATING ORBES PORTION OF STATE CONSUMPTION OF NATURAL GAS IN REFINING[1]

| State | Illinois | Indiana | Kentucky | Ohio | Pennsylvania | West Virginia |
|---|---|---|---|---|---|---|
| Factors | 1 | 0 | 1 | 0 | 1 | 1 |

1. Calculated from capacity data in Oil and Gas Journal, July 11, 1977, pp. 82-132.

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TABLE D-5

FACTORS FOR ALLOCATING ORBES PORTION OF STATE LOSSES AND OMISSIONS BY FUEL AND ELECTRIC GENERATION

| State | Sector | |
|---|---|---|
| Illinois | Petroleum products[1] | = 0.49 |
| | Natural gas[1] | = 0.63 |
| | Coal[1] | = 0.67 |
| | Electricity[2] | = 0.54 |
| Indiana | Petroleum products[1] | = 0.42 |
| | Natural gas[1] | = 0.18 |
| | Coal[1] | = 0.79 |
| | Electricity[2] | = 0.77 |
| Kentucky | Petroleum products[1] | = 1.00 |
| | Natural gas[1] | = 1.00 |
| | Coal[1] | = 1.00 |
| | Electricity[2] | = 1.00 |
| Ohio | Petroleum products[1] | = 0.52 |
| | Natural gas[1] | = 0.50 |
| | Coal[1] | = 0.81 |
| | Electricity[2] | = 0.78 |
| Pennsylvania | Petroleum products[1] | = 0.07 |
| | Natural gas[1] | = 0.50 |
| | Coal[1] | = 0.64 |
| | Electricity[2] | = 0.43 |
| West Virginia | Petroleum products[1] | = 1.00 |
| | Natural gas[1] | = 1.00 |
| | Coal[1] | = 1.00 |
| | Electricity[2] | = 1.00 |

1. Ratio of CRBES generating capacity to total state generating capacity.

2. Average of ORBES generating and refining factors for each fuel.

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